FILE

STORMWATER ANALYSIS & CALCULATIONS REPORT

for

44 ESTABROOK AVENUE
GRAFTON, MASSACHUSETTS
(PHASE 3 SOLAR DEVELOPMENT)

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EXHIBIT 4

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TABLE OF CONTENTS

CALCULATION METHODS

- TR 20 SCS Unit Hydrograph Procedure
- Runoff Curve Numbers
- Time of Concentration by TR55 Methodology
- Reach and Pond Rating by the Storage-Indication Method
- Manning Equation

SOURCE OF DATA

- Technical Report No. 20
- Technical Report No. 55
- Technical Paper No. 40
- Field Survey by Meridian Associates, Inc.
- Soil Testing by Meridian Associates, Inc.
- Massachusetts Stormwater Handbook February 2008

REPORT SUMMARY:

Calculation Objective

The purpose of this drainage analysis is to design a stormwater management system that will not increase peak rates and volumes of stormwater runoff that will flow offsite from pre to post development at the selected design points during the 2, 10, and 100-year design storm events.

The following analysis is separated into existing conditions and proposed conditions for ease of comparison. Drainage maps have been incorporated into this report to depict existing and proposed watershed areas and subcatchments for the site.

Classification of Soils:

The drainage class of the various soil types on the locus property has been categorized by applying the information provided by the soil maps prepared by the United States Department of Agriculture, National Resource Conservation Service (hereon referred to as the USDA NRCS). Based upon the USDA NRCS Soil Maps, four (4) soil groups exist within the subcatchment areas that are used throughout this drainage analysis. The four different soil types are as follows:

- Paxton Fine Sandy Loam, 3-8% Slopes, Very Stony, Hydrological Soil Group C;
- Paxton Fine Sandy Loam, 8-15% Slopes, Very Stony, Hydrological Soil Group C;
- Woodbridge Fine Sandy Loam, 0-8% slopes, Extremely Stony, Hydrological Soil Group C;
- Woodbridge Fine Sandy Loam, 3-8% slopes, Extremely Stony, Hydrological Soil Group C;

Paxton Fine Sandy Loam, 3-8% Slopes

This unit consists of very deep, strongly sloping, well-drained soil on drumlin and drumlin like areas. Seasonal high groundwater is typically found at depths of 18-37" below the existing grade. Parent material is Coarse-loamy lodgment till derived from gneiss, granite, and/or schist. The permeability of this soil is moderate in the subsoil and slow or very slow in the substratum.

Paxton Fine Sandy Loam, 18-15% Slopes

This unit consists of deep, moderately steep, well-drained soil on drumlins. Seasonal high groundwater is typically found at depths of 18-37" below the existing grade. Parent material is coarse-loamy lodgment till derived from gneiss, granite, and/or schist. The permeability of this soil is moderate in the subsoil and slow or very slow in the substratum.

Woodbridge Fine Sandy Loam, 0-8% slopes, Extremely Stony

This unit consists of very deep, gently sloping, moderately well-drained soil on the tops of drumlins and on glacial till uplands. Seasonal high groundwater is typically found at depths of 19-27" below the existing grade. Parent material is coarse-loamy lodgment till derived from gneiss, granite, and/or schist. The permeability of this soil is moderate in the subsoil and slow or very slow in the substratum.

Woodbridge Fine Sandy Loam, 3-8% slopes

This unit consists of very deep, gently sloping, moderately well-drained soil on the tops of drumlins and on glacial till uplands. Seasonal high groundwater is typically found at depths of 19-27" below the existing grade. Parent material is coarse-loamy lodgment till derived from gneiss, granite, and/or schist. The permeability of this soil is moderate in the subsoil and slow or very slow in the substratum.

Selection of Storm Events

The storm event rainfall frequencies have been selected based upon the Massachusetts Stormwater Guidelines requirements. Storm event rainfall data has been compiled from Technical Release No. 55, Urban Hydrology for Small Watersheds, 2nd Edition, prepared by the U.S. Soil Conservation Service. Rainfall frequency data has been provided as follows:

Frequency (Years)	Rainfall [24 hour event (inches)]
2	3.0
10	4.5
100	6.5

Existing Site Overview

The project area is bordered by undeveloped land to the east and west with agricultural fields to the south with agricultural fields and solar farms to the north on the opposite side of Estabrook Avenue. The majority of the area included within the drainage analysis currently slopes west to east and east to west toward two existing resource areas. The stormwater runoff patterns established within the pre-development conditions are based on existing topography which indicates that the runoff flows to one (1) of two (2) design points which are listed below:

- Design Point #1 **(DP1)** is the existing resource area to the west/northwest.
- Design Point #2 **(DP2)** is the existing resource area to the northeast.

The existing site has been broken into two (2) subcatchments as depicted on the Pre-Development Drainage Plan. The following summarizes the various hydraulic conditions and areas comprising the pre-hydrologic model:

- **Subcatchment S1 –** This is denoted as S1 on the accompanying Pre-Development Drainage Plan. The subcatchment area consists of wooded land, meadow grass, maintained grass areas and a dirt road. Stormwater runoff generated in this subcatchment flows to the existing resource area to the north of the field and south of Estabrook Avenue. **(DP1)**.

- **Subcatchment S2 –** This is denoted as S2 on the accompanying Pre-Development Drainage Plan. The subcatchment area consists of wooded land, meadow grass, maintained grass areas and a dirt road. Stormwater runoff generated in this subcatchment flows to the existing resource area to the west/northwest of the field and south of Estabrook Avenue. **(DP1)**.

Proposed Site Overview

The proposed project is comprised of the development of a solar electric generating facility, the construction of a gravel access road, water quality swales, sedimentation basins, inverter/transformer stations, interconnection equipment, electrical conduit, new utility poles and risers, fencing, gates, and associated seeding and stabilization. The existing runoff patterns will be maintained with limited selective grading. The proposed solar facility will be installed using a screw and/or post system which minimizes impact on the existing topography and reduces the need for excess earthwork.

A drainage system consisting of water quality swales and sedimentation basins are proposed to provide water quality treatment for the gravel access drive as well as nitrogen removal. Additionally, peak rates of stormwater runoff in the proposed conditions will not result in an increase in the 2, 10, and 100-year storm events at the selected design points.

The proposed site has been broken into subcatchments as depicted on the Post-Development Drainage Plan. The following summarizes the various hydraulic conditions and areas comprising the post-hydrologic model.

- **Subcatchment S10** – This is denoted as S10 on the accompanying Pre-Development Drainage Plan. The subcatchment area consists of wooded land, meadow grass and "Solar Farm Seed Mix" grassed areas and "Wetmix" grassed areas, portions of the gravel drive, water quality swale and sedimentation basin. Stormwater runoff generated in this subcatchment flows to the existing resource area to the north of the field and south of Estabrook Avenue. **(DP10)**.

- **Subcatchment S20** – This is denoted as S10 on the accompanying Pre-Development Drainage Plan. The subcatchment area consists of wooded land, meadow grass and "Solar Farm Seed Mix" grassed areas and "Wetmix" grassed areas, portions of the gravel drive, water quality swale and sedimentation basin. Stormwater runoff generated in this subcatchment flows to the existing resource area to the west/northwest of the field and south of Estabrook Avenue. **(DP20)**.

The following Table demonstrates the peak flows and volumes resulting from the stormwater analysis described in this report.

STORMWATER ANALYSIS

Summary of Flows at Design Points 1 and 10

Storm Event	Existing Conditions (Pre) Peak Flow (CFS)	Proposed Conditions (Post) Peak Flow (CFS)
2-Year (3.00 in./hr.)	12.44	11.25
10-Year (4.50 in./hr.)	30.64	26.84
100-Year (6.50 in./hr.)	58.64	52.15

Summary of Flows at Design Points 2 and 20

Storm Event	Existing Conditions (Pre) Peak Flow (CFS)	Proposed Conditions (Post) Peak Flow (CFS)
2-Year (3.00 in./hr.)	10.08	7.28
10-Year (4.50 in./hr.)	25.38	18.05
100-Year (6.50 in./hr.)	49.26	38.48

* CFS – Cubic Feet Per Second
* AF – Acre Feet

Conclusion

The calculations demonstrate that the proposed development will not result in an increase in the peak rate of stormwater runoff for the 2-year, 10-year, or 100-year 24-hour storm events at the selected design points.

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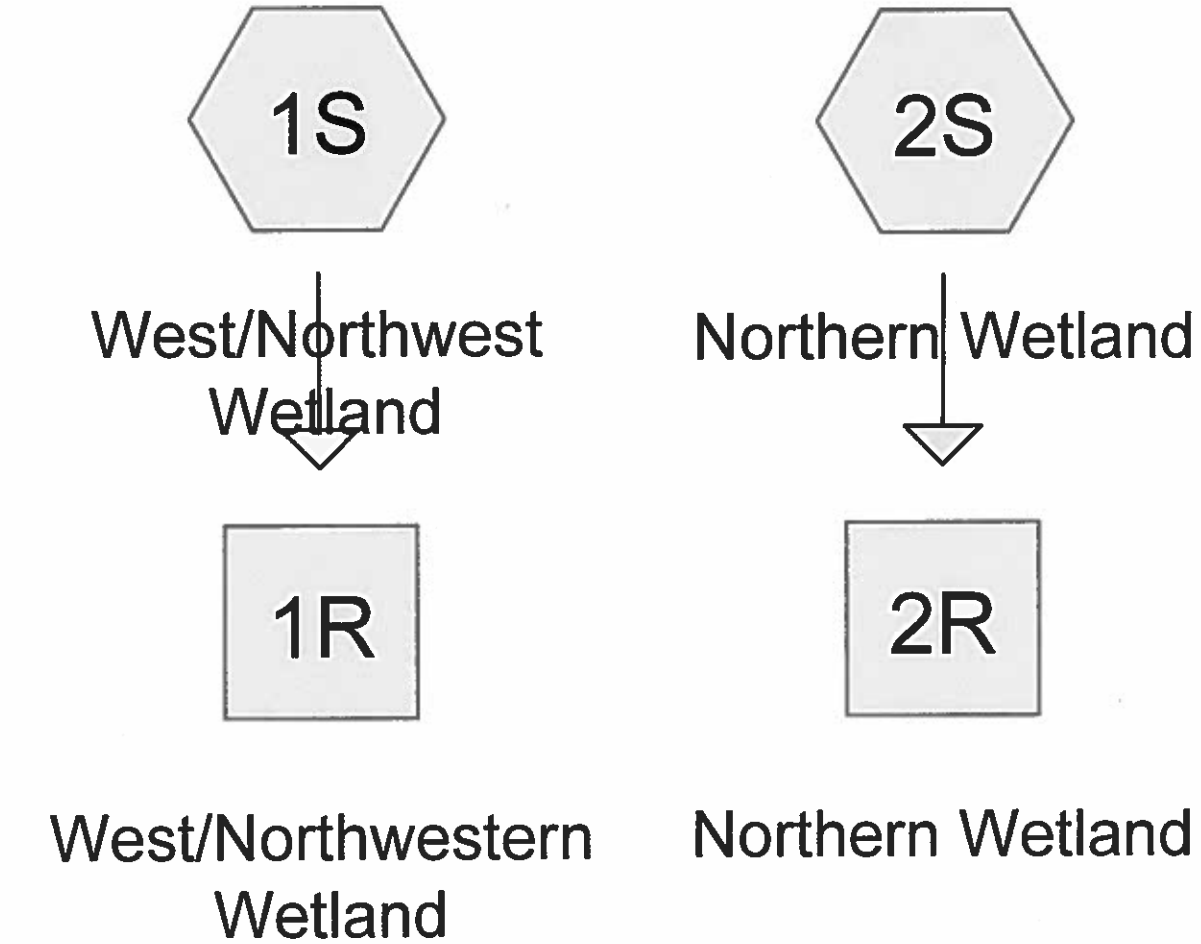
EXISTING CONDITIONS
STORMWATER CALCULATIONS



Subcat Reach Pond Link

Routing Diagram for 6108_PRE
Prepared by Meridian Associates, Printed 6/5/2018

Area Listing (all nodes)

Area (sq-ft)	CN	Description (subcatchment-numbers)
1,022,666	70	Woods, Good, HSG C (1S, 2S)
765,034	74	Pasture/grassland/range, Good, HSG C (1S, 2S)
15,268	89	Gravel roads, HSG C (1S, 2S)
1,802,968	**72**	**TOTAL AREA**

Summary for Subcatchment 1S: West/Northwest Wetland

Runoff = 12.44 cfs @ 12.24 hrs, Volume= 52,259 cf, Depth> 0.73"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 5.00-20.00 hrs, dt= 0.05 hrs
Type III 24-hr 2-Year Rainfall=3.00"

Area (sf)	CN	Description
9,559	89	Gravel roads, HSG C
363,247	70	Woods, Good, HSG C
489,187	74	Pasture/grassland/range, Good, HSG C
861,993	72	Weighted Average
861,993		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
8.1	50	0.0600	0.10		**Sheet Flow, Sheet Flow** Woods: Light underbrush n= 0.400 P2= 3.10"
5.2	537	0.0600	1.71		**Shallow Concentrated Flow, Shallow Concentrated Flow** Short Grass Pasture Kv= 7.0 fps
2.3	210	0.0950	1.54		**Shallow Concentrated Flow, Shallow Concentrated Flow** Woodland Kv= 5.0 fps
15.6	797	Total			

Summary for Subcatchment 2S: Northern Wetland

Runoff = 10.08 cfs @ 12.43 hrs, Volume= 53,206 cf, Depth> 0.68"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 5.00-20.00 hrs, dt= 0.05 hrs
Type III 24-hr 2-Year Rainfall=3.00"

Area (sf)	CN	Description
5,709	89	Gravel roads, HSG C
659,419	70	Woods, Good, HSG C
275,847	74	Pasture/grassland/range, Good, HSG C
940,975	71	Weighted Average
940,975		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
9.5	50	0.0400	0.09		**Sheet Flow, Sheet Flow** Woods: Light underbrush n= 0.400 P2= 3.10"
12.9	840	0.0470	1.08		**Shallow Concentrated Flow, Shallow Concentrated Flow** Woodland Kv= 5.0 fps
0.1	35	0.5700	5.28		**Shallow Concentrated Flow, Shallow Concentrated Flow** Short Grass Pasture Kv= 7.0 fps
2.3	140	0.0430	1.04		**Shallow Concentrated Flow, Shallow Concentrated Flow** Woodland Kv= 5.0 fps
0.7	87	0.0920	2.12		**Shallow Concentrated Flow, Shallow Concentrated Flow** Short Grass Pasture Kv= 7.0 fps
1.7	155	0.0900	1.50		**Shallow Concentrated Flow, Shallow Concentrated Flow** Woodland Kv= 5.0 fps
27.2	1,307	Total			

Summary for Reach 1R: West/Northwestern Wetland

Inflow Area = 861,993 sf, 0.00% Impervious, Inflow Depth > 0.73" for 2-Year event
Inflow = 12.44 cfs @ 12.24 hrs, Volume= 52,259 cf
Outflow = 12.44 cfs @ 12.24 hrs, Volume= 52,259 cf, Atten= 0%, Lag= 0.0 min

Routing by Stor-Ind+Trans method, Time Span= 5.00-20.00 hrs, dt= 0.05 hrs

Summary for Reach 2R: Northern Wetland

Inflow Area = 940,975 sf, 0.00% Impervious, Inflow Depth > 0.68" for 2-Year event
Inflow = 10.08 cfs @ 12.43 hrs, Volume= 53,206 cf
Outflow = 10.08 cfs @ 12.43 hrs, Volume= 53,206 cf, Atten= 0%, Lag= 0.0 min

Routing by Stor-Ind+Trans method, Time Span= 5.00-20.00 hrs, dt= 0.05 hrs

Summary for Subcatchment 1S: West/Northwest Wetland

Runoff = 30.64 cfs @ 12.22 hrs, Volume= 119,917 cf, Depth> 1.67"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 5.00-20.00 hrs, dt= 0.05 hrs
Type III 24-hr 10-Year Rainfall=4.50"

Area (sf)	CN	Description
9,559	89	Gravel roads, HSG C
363,247	70	Woods, Good, HSG C
489,187	74	Pasture/grassland/range, Good, HSG C
861,993	72	Weighted Average
861,993		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
8.1	50	0.0600	0.10		**Sheet Flow, Sheet Flow** Woods: Light underbrush n= 0.400 P2= 3.10"
5.2	537	0.0600	1.71		**Shallow Concentrated Flow, Shallow Concentrated Flow** Short Grass Pasture Kv= 7.0 fps
2.3	210	0.0950	1.54		**Shallow Concentrated Flow, Shallow Concentrated Flow** Woodland Kv= 5.0 fps
15.6	797	Total			

Summary for Subcatchment 2S: Northern Wetland

Runoff = 25.38 cfs @ 12.40 hrs, Volume= 124,750 cf, Depth> 1.59"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 5.00-20.00 hrs, dt= 0.05 hrs
Type III 24-hr 10-Year Rainfall=4.50"

Area (sf)	CN	Description
5,709	89	Gravel roads, HSG C
659,419	70	Woods, Good, HSG C
275,847	74	Pasture/grassland/range, Good, HSG C
940,975	71	Weighted Average
940,975		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
9.5	50	0.0400	0.09		**Sheet Flow, Sheet Flow** Woods: Light underbrush n= 0.400 P2= 3.10"
12.9	840	0.0470	1.08		**Shallow Concentrated Flow, Shallow Concentrated Flow** Woodland Kv= 5.0 fps
0.1	35	0.5700	5.28		**Shallow Concentrated Flow, Shallow Concentrated Flow** Short Grass Pasture Kv= 7.0 fps
2.3	140	0.0430	1.04		**Shallow Concentrated Flow, Shallow Concentrated Flow** Woodland Kv= 5.0 fps
0.7	87	0.0920	2.12		**Shallow Concentrated Flow, Shallow Concentrated Flow** Short Grass Pasture Kv= 7.0 fps
1.7	155	0.0900	1.50		**Shallow Concentrated Flow, Shallow Concentrated Flow** Woodland Kv= 5.0 fps
27.2	1,307	Total			

Summary for Reach 1R: West/Northwestern Wetland

Inflow Area = 861,993 sf, 0.00% Impervious, Inflow Depth > 1.67" for 10-Year event
Inflow = 30.64 cfs @ 12.22 hrs, Volume= 119,917 cf
Outflow = 30.64 cfs @ 12.22 hrs, Volume= 119,917 cf, Atten= 0%, Lag= 0.0 min

Routing by Stor-Ind+Trans method, Time Span= 5.00-20.00 hrs, dt= 0.05 hrs

Summary for Reach 2R: Northern Wetland

Inflow Area = 940,975 sf, 0.00% Impervious, Inflow Depth > 1.59" for 10-Year event
Inflow = 25.38 cfs @ 12.40 hrs, Volume= 124,750 cf
Outflow = 25.38 cfs @ 12.40 hrs, Volume= 124,750 cf, Atten= 0%, Lag= 0.0 min

Routing by Stor-Ind+Trans method, Time Span= 5.00-20.00 hrs, dt= 0.05 hrs

Summary for Subcatchment 1S: West/Northwest Wetland

Runoff = 58.64 cfs @ 12.22 hrs, Volume= 226,933 cf, Depth> 3.16"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 5.00-20.00 hrs, dt= 0.05 hrs
Type III 24-hr 100-Year Rainfall=6.50"

Area (sf)	CN	Description
9,559	89	Gravel roads, HSG C
363,247	70	Woods, Good, HSG C
489,187	74	Pasture/grassland/range, Good, HSG C
861,993	72	Weighted Average
861,993		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
8.1	50	0.0600	0.10		**Sheet Flow, Sheet Flow** Woods: Light underbrush n= 0.400 P2= 3.10"
5.2	537	0.0600	1.71		**Shallow Concentrated Flow, Shallow Concentrated Flow** Short Grass Pasture Kv= 7.0 fps
2.3	210	0.0950	1.54		**Shallow Concentrated Flow, Shallow Concentrated Flow** Woodland Kv= 5.0 fps
15.6	797	Total			

Summary for Subcatchment 2S: Northern Wetland

Runoff = 49.26 cfs @ 12.38 hrs, Volume= 239,121 cf, Depth> 3.05"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 5.00-20.00 hrs, dt= 0.05 hrs
Type III 24-hr 100-Year Rainfall=6.50"

Area (sf)	CN	Description
5,709	89	Gravel roads, HSG C
659,419	70	Woods, Good, HSG C
275,847	74	Pasture/grassland/range, Good, HSG C
940,975	71	Weighted Average
940,975		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
9.5	50	0.0400	0.09		**Sheet Flow, Sheet Flow** Woods: Light underbrush n= 0.400 P2= 3.10"
12.9	840	0.0470	1.08		**Shallow Concentrated Flow, Shallow Concentrated Flow** Woodland Kv= 5.0 fps
0.1	35	0.5700	5.28		**Shallow Concentrated Flow, Shallow Concentrated Flow** Short Grass Pasture Kv= 7.0 fps
2.3	140	0.0430	1.04		**Shallow Concentrated Flow, Shallow Concentrated Flow** Woodland Kv= 5.0 fps
0.7	87	0.0920	2.12		**Shallow Concentrated Flow, Shallow Concentrated Flow** Short Grass Pasture Kv= 7.0 fps
1.7	155	0.0900	1.50		**Shallow Concentrated Flow, Shallow Concentrated Flow** Woodland Kv= 5.0 fps
27.2	1,307	Total			

Summary for Reach 1R: West/Northwestern Wetland

Inflow Area = 861,993 sf, 0.00% Impervious, Inflow Depth > 3.16" for 100-Year event
Inflow = 58.64 cfs @ 12.22 hrs, Volume= 226,933 cf
Outflow = 58.64 cfs @ 12.22 hrs, Volume= 226,933 cf, Atten= 0%, Lag= 0.0 min

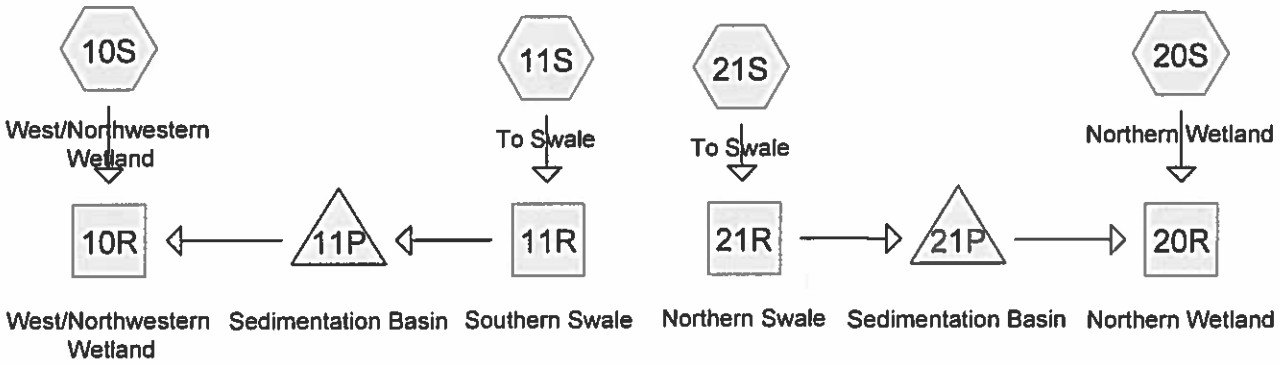
Routing by Stor-Ind+Trans method, Time Span= 5.00-20.00 hrs, dt= 0.05 hrs

Summary for Reach 2R: Northern Wetland

Inflow Area = 940,975 sf, 0.00% Impervious, Inflow Depth > 3.05" for 100-Year event
Inflow = 49.26 cfs @ 12.38 hrs, Volume= 239,121 cf
Outflow = 49.26 cfs @ 12.38 hrs, Volume= 239,121 cf, Atten= 0%, Lag= 0.0 min

Routing by Stor-Ind+Trans method, Time Span= 5.00-20.00 hrs, dt= 0.05 hrs

PROPOSED CONDITIONS
STORMWATER CALCULATIONS



Subcat Reach Pond Link

Routing Diagram for 6108_POST
Prepared by Meridian Associates, Printed 6/5/2018

Area Listing (all nodes)

Area (sq-ft)	CN	Description (subcatchment-numbers)
559,656	70	Woods, Good, HSG C (10S, 20S, 21S)
1,201,583	74	Pasture/grassland/range, Good, HSG C (10S, 11S, 20S, 21S)
30,729	89	Gravel roads, HSG C (20S, 21S)
11,000	96	Gravel surface, HSG C (10S)
1,802,968	**73**	**TOTAL AREA**

Summary for Subcatchment 10S: West/Northwestern Wetland

Runoff = 11.25 cfs @ 12.16 hrs, Volume= 43,700 cf, Depth> 0.86"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 5.00-24.00 hrs, dt= 0.05 hrs
Type III 24-hr 2-Year Rainfall=3.00"

Area (sf)	CN	Description
11,000	96	Gravel surface, HSG C
232,366	70	Woods, Good, HSG C
369,736	74	Pasture/grassland/range, Good, HSG C
613,102	73	Weighted Average
613,102		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
5.4	50	0.0600	0.16		**Sheet Flow, Sheet Flow** Grass: Dense n= 0.240 P2= 3.10"
4.5	577	0.0919	2.12		**Shallow Concentrated Flow, Shallow Concentrated Flow** Short Grass Pasture Kv= 7.0 fps
9.9	627	Total			

Summary for Subcatchment 11S: To Swale

Runoff = 3.86 cfs @ 12.29 hrs, Volume= 18,745 cf, Depth> 0.90"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 5.00-24.00 hrs, dt= 0.05 hrs
Type III 24-hr 2-Year Rainfall=3.00"

Area (sf)	CN	Description
248,891	74	Pasture/grassland/range, Good, HSG C
248,891		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
5.4	50	0.0600	0.16		**Sheet Flow, Sheet Flow** Grass: Dense n= 0.240 P2= 3.10"
13.7	1,150	0.0400	1.40		**Shallow Concentrated Flow, Shallow Concentrated Flow** Short Grass Pasture Kv= 7.0 fps
19.1	1,200	Total			

Summary for Subcatchment 20S: Northern Wetland

Runoff = 7.28 cfs @ 12.29 hrs, Volume= 36,045 cf, Depth> 0.80"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 5.00-24.00 hrs, dt= 0.05 hrs
Type III 24-hr 2-Year Rainfall=3.00"

Area (sf)	CN	Description
6,690	89	Gravel roads, HSG C
313,580	70	Woods, Good, HSG C
217,693	74	Pasture/grassland/range, Good, HSG C
537,963	72	Weighted Average
537,963		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
9.5	50	0.0400	0.09		**Sheet Flow, Sheet Flow** Woods: Light underbrush n= 0.400 P2= 3.10"
9.0	775	0.0826	1.44		**Shallow Concentrated Flow, Shallow Concentrated Flow** Woodland Kv= 5.0 fps
18.5	825	Total			

Summary for Subcatchment 21S: To Swale

Runoff = 6.07 cfs @ 12.37 hrs, Volume= 32,065 cf, Depth> 0.95"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 5.00-24.00 hrs, dt= 0.05 hrs
Type III 24-hr 2-Year Rainfall=3.00"

Area (sf)	CN	Description
24,039	89	Gravel roads, HSG C
365,263	74	Pasture/grassland/range, Good, HSG C
13,710	70	Woods, Good, HSG C
403,012	75	Weighted Average
403,012		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
9.5	50	0.0400	0.09		**Sheet Flow, Sheet Flow** Woods: Light underbrush n= 0.400 P2= 3.10"
7.4	310	0.0194	0.70		**Shallow Concentrated Flow, Shallow Concentrated Flow** Woodland Kv= 5.0 fps
7.3	748	0.0598	1.71		**Shallow Concentrated Flow, Shallow Concentrated Flow** Short Grass Pasture Kv= 7.0 fps
0.1	20	0.0900	4.83		**Shallow Concentrated Flow, Shallow Concentrated Flow** Unpaved Kv= 16.1 fps
0.1	17	0.1100	2.32		**Shallow Concentrated Flow, Shallow Concentrated Flow** Short Grass Pasture Kv= 7.0 fps
24.4	1,145	Total			

Summary for Reach 10R: West/Northwestern Wetland

Inflow Area = 861,993 sf, 0.00% Impervious, Inflow Depth > 0.84" for 2-Year event
Inflow = 11.25 cfs @ 12.16 hrs, Volume= 60,485 cf
Outflow = 11.25 cfs @ 12.16 hrs, Volume= 60,485 cf, Atten= 0%, Lag= 0.0 min

Routing by Stor-Ind+Trans method, Time Span= 5.00-24.00 hrs, dt= 0.05 hrs

Summary for Reach 11R: Southern Swale

Inflow Area = 248,891 sf, 0.00% Impervious, Inflow Depth > 0.90" for 2-Year event
Inflow = 3.86 cfs @ 12.29 hrs, Volume= 18,745 cf
Outflow = 3.02 cfs @ 12.72 hrs, Volume= 18,370 cf, Atten= 22%, Lag= 25.6 min

Routing by Stor-Ind+Trans method, Time Span= 5.00-24.00 hrs, dt= 0.05 hrs
Max. Velocity= 1.22 fps, Min. Travel Time= 14.5 min
Avg. Velocity = 0.53 fps, Avg. Travel Time= 33.1 min

Peak Storage= 2,622 cf @ 12.48 hrs
Average Depth at Peak Storage= 0.46'
Bank-Full Depth= 2.00' Flow Area= 20.0 sf, Capacity= 54.71 cfs

4.00' x 2.00' deep channel, n= 0.080 Earth, long dense weeds
Side Slope Z-value= 3.0 '/' Top Width= 16.00'
Length= 1,060.0' Slope= 0.0170 '/'
Inlet Invert= 435.00', Outlet Invert= 417.00'

‡

Summary for Reach 20R: Northern Wetland

Inflow Area = 940,975 sf, 0.00% Impervious, Inflow Depth > 0.81" for 2-Year event
Inflow = 7.28 cfs @ 12.29 hrs, Volume= 63,534 cf
Outflow = 7.28 cfs @ 12.29 hrs, Volume= 63,534 cf, Atten= 0%, Lag= 0.0 min

Routing by Stor-Ind+Trans method, Time Span= 5.00-24.00 hrs, dt= 0.05 hrs

Summary for Reach 21R: Northern Swale

Inflow Area = 403,012 sf, 0.00% Impervious, Inflow Depth > 0.95" for 2-Year event
Inflow = 6.07 cfs @ 12.37 hrs, Volume= 32,065 cf
Outflow = 5.02 cfs @ 12.77 hrs, Volume= 31,486 cf, Atten= 17%, Lag= 24.3 min

Routing by Stor-Ind+Trans method, Time Span= 5.00-24.00 hrs, dt= 0.05 hrs
Max. Velocity= 1.37 fps, Min. Travel Time= 13.7 min
Avg. Velocity = 0.61 fps, Avg. Travel Time= 30.6 min

Peak Storage= 4,147 cf @ 12.55 hrs
Average Depth at Peak Storage= 0.63'
Bank-Full Depth= 2.00' Flow Area= 20.0 sf, Capacity= 51.61 cfs

4.00' x 2.00' deep channel, n= 0.080 Earth, long dense weeds
Side Slope Z-value= 3.0 '/' Top Width= 16.00'
Length= 1,125.0' Slope= 0.0151 '/'
Inlet Invert= 433.00', Outlet Invert= 416.00'

‡

Summary for Pond 11P: Sedimentation Basin

Inflow Area = 248,891 sf, 0.00% Impervious, Inflow Depth > 0.89" for 2-Year event
Inflow = 3.02 cfs @ 12.72 hrs, Volume= 18,370 cf
Outflow = 2.13 cfs @ 13.02 hrs, Volume= 16,786 cf, Atten= 30%, Lag= 18.2 min
Primary = 2.13 cfs @ 13.02 hrs, Volume= 16,786 cf

Routing by Stor-Ind method, Time Span= 5.00-24.00 hrs, dt= 0.05 hrs
Peak Elev= 415.33' @ 13.02 hrs Surf.Area= 2,522 sf Storage= 3,728 cf

Plug-Flow detention time= 72.3 min calculated for 16,786 cf (91% of inflow)
Center-of-Mass det. time= 32.2 min (935.9 - 903.7)

Volume	Invert	Avail.Storage	Storage Description
#1	413.00'	16,493 cf	**Custom Stage Data (Prismatic)**Listed below (Recalc)

Elevation (feet)	Surf.Area (sq-ft)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)
413.00	0	0	0
414.00	1,762	881	881
415.00	2,318	2,040	2,921
416.00	2,930	2,624	5,545
417.00	3,996	3,463	9,008
418.00	5,177	4,587	13,595
418.50	6,415	2,898	16,493

Device	Routing	Invert	Outlet Devices
#1	Primary	417.50'	**20.0' long x 5.0' breadth Broad-Crested Rectangular Weir** Head (feet) 0.20 0.40 0.60 0.80 1.00 1.20 1.40 1.60 1.80 2.00 2.50 3.00 3.50 4.00 4.50 5.00 5.50 Coef. (English) 2.34 2.50 2.70 2.68 2.68 2.66 2.65 2.65 2.65 2.65 2.67 2.66 2.68 2.70 2.74 2.79 2.88
#2	Primary	414.25'	**12.0" Round 12" Culvert** L= 55.0' CPP, mitered to conform to fill, Ke= 0.700 Inlet / Outlet Invert= 414.25' / 414.25' S= 0.0000 '/' Cc= 0.900 n= 0.010 PVC, smooth interior, Flow Area= 0.79 sf
#3	Primary	414.00'	**4.0" Round 4" Culvert** L= 40.0' CPP, mitered to conform to fill, Ke= 0.700 Inlet / Outlet Invert= 414.00' / 414.00' S= 0.0000 '/' Cc= 0.900 n= 0.010 PVC, smooth interior, Flow Area= 0.09 sf

Primary OutFlow Max=2.12 cfs @ 13.02 hrs HW=415.33' (Free Discharge)
↑—**1=Broad-Crested Rectangular Weir**(Controls 0.00 cfs)
—**2=12" Culvert** (Barrel Controls 1.81 cfs @ 2.65 fps)
—**3=4" Culvert** (Barrel Controls 0.32 cfs @ 3.62 fps)

Summary for Pond 21P: Sedimentation Basin

Inflow Area = 403,012 sf, 0.00% Impervious, Inflow Depth > 0.94" for 2-Year event
Inflow = 5.02 cfs @ 12.77 hrs, Volume= 31,486 cf
Outflow = 3.30 cfs @ 13.14 hrs, Volume= 27,489 cf, Atten= 34%, Lag= 21.7 min
Primary = 3.30 cfs @ 13.14 hrs, Volume= 27,489 cf

Routing by Stor-Ind method, Time Span= 5.00-24.00 hrs, dt= 0.05 hrs
Peak Elev= 414.13' @ 13.14 hrs Surf.Area= 5,328 sf Storage= 7,716 cf

Plug-Flow detention time= 96.7 min calculated for 27,489 cf (87% of inflow)
Center-of-Mass det. time= 41.7 min (944.4 - 902.7)

Volume	Invert	Avail.Storage	Storage Description
#1	412.00'	22,938 cf	**Custom Stage Data (Prismatic)** Listed below (Recalc)

Elevation (feet)	Surf.Area (sq-ft)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)
412.00	0	0	0
413.00	4,400	2,200	2,200
414.00	5,211	4,806	7,006
415.00	6,079	5,645	12,651
416.00	7,003	6,541	19,192
416.50	7,984	3,747	22,938

Device	Routing	Invert	Outlet Devices
#1	Primary	415.50'	**20.0' long x 6.0' breadth Broad-Crested Rectangular Weir** Head (feet) 0.20 0.40 0.60 0.80 1.00 1.20 1.40 1.60 1.80 2.00 2.50 3.00 3.50 4.00 4.50 5.00 5.50 Coef. (English) 2.37 2.51 2.70 2.68 2.68 2.67 2.65 2.65 2.65 2.65 2.66 2.66 2.67 2.69 2.72 2.76 2.83
#2	Primary	413.25'	**12.0" Round 12" Culvert X 2.00** L= 20.0' CPP, mitered to conform to fill, Ke= 0.700 Inlet / Outlet Invert= 413.25' / 413.25' S= 0.0000 '/' Cc= 0.900 n= 0.010 PVC, smooth interior, Flow Area= 0.79 sf
#3	Primary	413.00'	**4.0" Round 4" Culvert** L= 20.0' CPP, mitered to conform to fill, Ke= 0.700 Inlet / Outlet Invert= 413.00' / 413.00' S= 0.0000 '/' Cc= 0.900 n= 0.010 PVC, smooth interior, Flow Area= 0.09 sf

Primary OutFlow Max=3.29 cfs @ 13.14 hrs HW=414.13' (Free Discharge)
- **1=Broad-Crested Rectangular Weir** (Controls 0.00 cfs)
- **2=12" Culvert** (Barrel Controls 2.95 cfs @ 2.66 fps)
- **3=4" Culvert** (Barrel Controls 0.34 cfs @ 3.95 fps)

Summary for Subcatchment 10S: West/Northwestern Wetland

Runoff = 26.67 cfs @ 12.15 hrs, Volume= 96,663 cf, Depth> 1.89"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 5.00-24.00 hrs, dt= 0.05 hrs
Type III 24-hr 10-Year Rainfall=4.50"

Area (sf)	CN	Description
11,000	96	Gravel surface, HSG C
232,366	70	Woods, Good, HSG C
369,736	74	Pasture/grassland/range, Good, HSG C
613,102	73	Weighted Average
613,102		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
5.4	50	0.0600	0.16		**Sheet Flow, Sheet Flow** Grass: Dense n= 0.240 P2= 3.10"
4.5	577	0.0919	2.12		**Shallow Concentrated Flow, Shallow Concentrated Flow** Short Grass Pasture Kv= 7.0 fps
9.9	627	Total			

Summary for Subcatchment 11S: To Swale

Runoff = 8.93 cfs @ 12.27 hrs, Volume= 40,740 cf, Depth> 1.96"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 5.00-24.00 hrs, dt= 0.05 hrs
Type III 24-hr 10-Year Rainfall=4.50"

Area (sf)	CN	Description
248,891	74	Pasture/grassland/range, Good, HSG C
248,891		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
5.4	50	0.0600	0.16		**Sheet Flow, Sheet Flow** Grass: Dense n= 0.240 P2= 3.10"
13.7	1,150	0.0400	1.40		**Shallow Concentrated Flow, Shallow Concentrated Flow** Short Grass Pasture Kv= 7.0 fps
19.1	1,200	Total			

Summary for Subcatchment 20S: Northern Wetland

Runoff = 17.88 cfs @ 12.27 hrs, Volume= 81,269 cf, Depth> 1.81"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 5.00-24.00 hrs, dt= 0.05 hrs
Type III 24-hr 10-Year Rainfall=4.50"

Area (sf)	CN	Description
6,690	89	Gravel roads, HSG C
313,580	70	Woods, Good, HSG C
217,693	74	Pasture/grassland/range, Good, HSG C
537,963	72	Weighted Average
537,963		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
9.5	50	0.0400	0.09		**Sheet Flow, Sheet Flow** Woods: Light underbrush n= 0.400 P2= 3.10"
9.0	775	0.0826	1.44		**Shallow Concentrated Flow, Shallow Concentrated Flow** Woodland Kv= 5.0 fps
18.5	825	Total			

Summary for Subcatchment 21S: To Swale

Runoff = 13.62 cfs @ 12.35 hrs, Volume= 68,496 cf, Depth> 2.04"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 5.00-24.00 hrs, dt= 0.05 hrs
Type III 24-hr 10-Year Rainfall=4.50"

Area (sf)	CN	Description
24,039	89	Gravel roads, HSG C
365,263	74	Pasture/grassland/range, Good, HSG C
13,710	70	Woods, Good, HSG C
403,012	75	Weighted Average
403,012		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
9.5	50	0.0400	0.09		**Sheet Flow, Sheet Flow** Woods: Light underbrush n= 0.400 P2= 3.10"
7.4	310	0.0194	0.70		**Shallow Concentrated Flow, Shallow Concentrated Flow** Woodland Kv= 5.0 fps
7.3	748	0.0598	1.71		**Shallow Concentrated Flow, Shallow Concentrated Flow** Short Grass Pasture Kv= 7.0 fps
0.1	20	0.0900	4.83		**Shallow Concentrated Flow, Shallow Concentrated Flow** Unpaved Kv= 16.1 fps
0.1	17	0.1100	2.32		**Shallow Concentrated Flow, Shallow Concentrated Flow** Short Grass Pasture Kv= 7.0 fps
24.4	1,145	Total			

Summary for Reach 10R: West/Northwestern Wetland

Inflow Area = 861,993 sf, 0.00% Impervious, Inflow Depth > 1.88" for 10-Year event
Inflow = 26.85 cfs @ 12.15 hrs, Volume= 135,079 cf
Outflow = 26.85 cfs @ 12.15 hrs, Volume= 135,079 cf, Atten= 0%, Lag= 0.0 min

Routing by Stor-Ind+Trans method, Time Span= 5.00-24.00 hrs, dt= 0.05 hrs

Summary for Reach 11R: Southern Swale

Inflow Area = 248,891 sf, 0.00% Impervious, Inflow Depth > 1.96" for 10-Year event
Inflow = 8.93 cfs @ 12.27 hrs, Volume= 40,740 cf
Outflow = 7.46 cfs @ 12.60 hrs, Volume= 40,203 cf, Atten= 16%, Lag= 19.4 min

Routing by Stor-Ind+Trans method, Time Span= 5.00-24.00 hrs, dt= 0.05 hrs
Max. Velocity= 1.60 fps, Min. Travel Time= 11.1 min
Avg. Velocity = 0.65 fps, Avg. Travel Time= 27.1 min

Peak Storage= 4,973 cf @ 12.41 hrs
Average Depth at Peak Storage= 0.75'
Bank-Full Depth= 2.00' Flow Area= 20.0 sf, Capacity= 54.71 cfs

4.00' x 2.00' deep channel, n= 0.080 Earth, long dense weeds
Side Slope Z-value= 3.0 '/' Top Width= 16.00'
Length= 1,060.0' Slope= 0.0170 '/'
Inlet Invert= 435.00', Outlet Invert= 417.00'

‡

Summary for Reach 20R: Northern Wetland

Inflow Area = 940,975 sf, 0.00% Impervious, Inflow Depth > 1.84" for 10-Year event
Inflow = 18.05 cfs @ 12.28 hrs, Volume= 144,578 cf
Outflow = 18.05 cfs @ 12.28 hrs, Volume= 144,578 cf, Atten= 0%, Lag= 0.0 min

Routing by Stor-Ind+Trans method, Time Span= 5.00-24.00 hrs, dt= 0.05 hrs

Summary for Reach 21R: Northern Swale

Inflow Area = 403,012 sf, 0.00% Impervious, Inflow Depth > 2.04" for 10-Year event
Inflow = 13.62 cfs @ 12.35 hrs, Volume= 68,496 cf
Outflow = 11.91 cfs @ 12.67 hrs, Volume= 67,668 cf, Atten= 13%, Lag= 18.9 min

Routing by Stor-Ind+Trans method, Time Span= 5.00-24.00 hrs, dt= 0.05 hrs
Max. Velocity= 1.75 fps, Min. Travel Time= 10.7 min
Avg. Velocity = 0.74 fps, Avg. Travel Time= 25.4 min

Peak Storage= 7,693 cf @ 12.48 hrs
Average Depth at Peak Storage= 0.98'
Bank-Full Depth= 2.00' Flow Area= 20.0 sf, Capacity= 51.61 cfs

4.00' x 2.00' deep channel, n= 0.080 Earth, long dense weeds
Side Slope Z-value= 3.0 '/' Top Width= 16.00'
Length= 1,125.0' Slope= 0.0151 '/'
Inlet Invert= 433.00', Outlet Invert= 416.00'

‡

Summary for Pond 11P: Sedimentation Basin

Inflow Area = 248,891 sf, 0.00% Impervious, Inflow Depth > 1.94" for 10-Year event
Inflow = 7.46 cfs @ 12.60 hrs, Volume= 40,203 cf
Outflow = 5.09 cfs @ 12.89 hrs, Volume= 38,416 cf, Atten= 32%, Lag= 17.6 min
Primary = 5.09 cfs @ 12.89 hrs, Volume= 38,416 cf

Routing by Stor-Ind method, Time Span= 5.00-24.00 hrs, dt= 0.05 hrs
Peak Elev= 416.70' @ 12.89 hrs Surf.Area= 3,677 sf Storage= 7,861 cf

Plug-Flow detention time= 46.1 min calculated for 38,416 cf (96% of inflow)
Center-of-Mass det. time= 23.2 min (898.3 - 875.0)

Volume	Invert	Avail.Storage	Storage Description
#1	413.00'	16,493 cf	**Custom Stage Data (Prismatic)**Listed below (Recalc)

Elevation (feet)	Surf.Area (sq-ft)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)
413.00	0	0	0
414.00	1,762	881	881
415.00	2,318	2,040	2,921
416.00	2,930	2,624	5,545
417.00	3,996	3,463	9,008
418.00	5,177	4,587	13,595
418.50	6,415	2,898	16,493

Device	Routing	Invert	Outlet Devices
#1	Primary	417.50'	**20.0' long x 5.0' breadth Broad-Crested Rectangular Weir** Head (feet) 0.20 0.40 0.60 0.80 1.00 1.20 1.40 1.60 1.80 2.00 2.50 3.00 3.50 4.00 4.50 5.00 5.50 Coef. (English) 2.34 2.50 2.70 2.68 2.68 2.66 2.65 2.65 2.65 2.65 2.67 2.66 2.68 2.70 2.74 2.79 2.88
#2	Primary	414.25'	**12.0" Round 12" Culvert** L= 55.0' CPP, mitered to conform to fill, Ke= 0.700 Inlet / Outlet Invert= 414.25' / 414.25' S= 0.0000 '/' Cc= 0.900 n= 0.010 PVC, smooth interior, Flow Area= 0.79 sf
#3	Primary	414.00'	**4.0" Round 4" Culvert** L= 40.0' CPP, mitered to conform to fill, Ke= 0.700 Inlet / Outlet Invert= 414.00' / 414.00' S= 0.0000 '/' Cc= 0.900 n= 0.010 PVC, smooth interior, Flow Area= 0.09 sf

Primary OutFlow Max=5.08 cfs @ 12.89 hrs HW=416.70' (Free Discharge)
↑—**1=Broad-Crested Rectangular Weir**(Controls 0.00 cfs)
—**2=12" Culvert** (Barrel Controls 4.60 cfs @ 5.85 fps)
—**3=4" Culvert** (Barrel Controls 0.49 cfs @ 5.57 fps)

Summary for Pond 21P: Sedimentation Basin

Inflow Area = 403,012 sf, 0.00% Impervious, Inflow Depth > 2.01" for 10-Year event
Inflow = 11.91 cfs @ 12.67 hrs, Volume= 67,668 cf
Outflow = 8.58 cfs @ 12.95 hrs, Volume= 63,309 cf, Atten= 28%, Lag= 17.0 min
Primary = 8.58 cfs @ 12.95 hrs, Volume= 63,309 cf

Routing by Stor-Ind method, Time Span= 5.00-24.00 hrs, dt= 0.05 hrs
Peak Elev= 415.21' @ 12.95 hrs Surf.Area= 6,270 sf Storage= 13,930 cf

Plug-Flow detention time= 58.8 min calculated for 63,143 cf (93% of inflow)
Center-of-Mass det. time= 27.4 min (903.1 - 875.6)

Volume	Invert	Avail.Storage	Storage Description
#1	412.00'	22,938 cf	**Custom Stage Data (Prismatic)** Listed below (Recalc)

Elevation (feet)	Surf.Area (sq-ft)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)
412.00	0	0	0
413.00	4,400	2,200	2,200
414.00	5,211	4,806	7,006
415.00	6,079	5,645	12,651
416.00	7,003	6,541	19,192
416.50	7,984	3,747	22,938

Device	Routing	Invert	Outlet Devices
#1	Primary	415.50'	**20.0' long x 6.0' breadth Broad-Crested Rectangular Weir** Head (feet) 0.20 0.40 0.60 0.80 1.00 1.20 1.40 1.60 1.80 2.00 2.50 3.00 3.50 4.00 4.50 5.00 5.50 Coef. (English) 2.37 2.51 2.70 2.68 2.68 2.67 2.65 2.65 2.65 2.65 2.66 2.66 2.67 2.69 2.72 2.76 2.83
#2	Primary	413.25'	**12.0" Round 12" Culvert X 2.00** L= 20.0' CPP, mitered to conform to fill, Ke= 0.700 Inlet / Outlet Invert= 413.25' / 413.25' S= 0.0000 '/' Cc= 0.900 n= 0.010 PVC, smooth interior, Flow Area= 0.79 sf
#3	Primary	413.00'	**4.0" Round 4" Culvert** L= 20.0' CPP, mitered to conform to fill, Ke= 0.700 Inlet / Outlet Invert= 413.00' / 413.00' S= 0.0000 '/' Cc= 0.900 n= 0.010 PVC, smooth interior, Flow Area= 0.09 sf

Primary OutFlow Max=8.58 cfs @ 12.95 hrs HW=415.21' (Free Discharge)
- **1=Broad-Crested Rectangular Weir** (Controls 0.00 cfs)
- **2=12" Culvert** (Inlet Controls 8.05 cfs @ 5.13 fps)
- **3=4" Culvert** (Barrel Controls 0.53 cfs @ 6.04 fps)

Summary for Subcatchment 10S: West/Northwestern Wetland

Runoff = 50.11 cfs @ 12.14 hrs, Volume= 178,915 cf, Depth> 3.50"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 5.00-24.00 hrs, dt= 0.05 hrs
Type III 24-hr 100-Year Rainfall=6.50"

Area (sf)	CN	Description
11,000	96	Gravel surface, HSG C
232,366	70	Woods, Good, HSG C
369,736	74	Pasture/grassland/range, Good, HSG C
613,102	73	Weighted Average
613,102		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
5.4	50	0.0600	0.16		**Sheet Flow, Sheet Flow** Grass: Dense n= 0.240 P2= 3.10"
4.5	577	0.0919	2.12		**Shallow Concentrated Flow, Shallow Concentrated Flow** Short Grass Pasture Kv= 7.0 fps
9.9	627	Total			

Summary for Subcatchment 11S: To Swale

Runoff = 16.58 cfs @ 12.27 hrs, Volume= 74,596 cf, Depth> 3.60"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 5.00-24.00 hrs, dt= 0.05 hrs
Type III 24-hr 100-Year Rainfall=6.50"

Area (sf)	CN	Description
248,891	74	Pasture/grassland/range, Good, HSG C
248,891		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
5.4	50	0.0600	0.16		**Sheet Flow, Sheet Flow** Grass: Dense n= 0.240 P2= 3.10"
13.7	1,150	0.0400	1.40		**Shallow Concentrated Flow, Shallow Concentrated Flow** Short Grass Pasture Kv= 7.0 fps
19.1	1,200	Total			

Summary for Subcatchment 20S: Northern Wetland

Runoff = 34.21 cfs @ 12.26 hrs, Volume= 152,179 cf, Depth> 3.39"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 5.00-24.00 hrs, dt= 0.05 hrs
Type III 24-hr 100-Year Rainfall=6.50"

Area (sf)	CN	Description
6,690	89	Gravel roads, HSG C
313,580	70	Woods, Good, HSG C
217,693	74	Pasture/grassland/range, Good, HSG C
537,963	72	Weighted Average
537,963		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
9.5	50	0.0400	0.09		**Sheet Flow, Sheet Flow** Woods: Light underbrush n= 0.400 P2= 3.10"
9.0	775	0.0826	1.44		**Shallow Concentrated Flow, Shallow Concentrated Flow** Woodland Kv= 5.0 fps
18.5	825	Total			

Summary for Subcatchment 21S: To Swale

Runoff = 24.91 cfs @ 12.34 hrs, Volume= 124,086 cf, Depth> 3.69"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 5.00-24.00 hrs, dt= 0.05 hrs
Type III 24-hr 100-Year Rainfall=6.50"

Area (sf)	CN	Description
24,039	89	Gravel roads, HSG C
365,263	74	Pasture/grassland/range, Good, HSG C
13,710	70	Woods, Good, HSG C
403,012	75	Weighted Average
403,012		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
9.5	50	0.0400	0.09		**Sheet Flow, Sheet Flow** Woods: Light underbrush n= 0.400 P2= 3.10"
7.4	310	0.0194	0.70		**Shallow Concentrated Flow, Shallow Concentrated Flow** Woodland Kv= 5.0 fps
7.3	748	0.0598	1.71		**Shallow Concentrated Flow, Shallow Concentrated Flow** Short Grass Pasture Kv= 7.0 fps
0.1	20	0.0900	4.83		**Shallow Concentrated Flow, Shallow Concentrated Flow** Unpaved Kv= 16.1 fps
0.1	17	0.1100	2.32		**Shallow Concentrated Flow, Shallow Concentrated Flow** Short Grass Pasture Kv= 7.0 fps
24.4	1,145	Total			

Summary for Reach 10R: West/Northwestern Wetland

Inflow Area = 861,993 sf, 0.00% Impervious, Inflow Depth > 3.49" for 100-Year event
Inflow = 52.16 cfs @ 12.15 hrs, Volume= 250,824 cf
Outflow = 52.16 cfs @ 12.15 hrs, Volume= 250,824 cf, Atten= 0%, Lag= 0.0 min

Routing by Stor-Ind+Trans method, Time Span= 5.00-24.00 hrs, dt= 0.05 hrs

Summary for Reach 11R: Southern Swale

Inflow Area = 248,891 sf, 0.00% Impervious, Inflow Depth > 3.60" for 100-Year event
Inflow = 16.58 cfs @ 12.27 hrs, Volume= 74,596 cf
Outflow = 14.40 cfs @ 12.53 hrs, Volume= 73,873 cf, Atten= 13%, Lag= 15.9 min

Routing by Stor-Ind+Trans method, Time Span= 5.00-24.00 hrs, dt= 0.05 hrs
Max. Velocity= 1.92 fps, Min. Travel Time= 9.2 min
Avg. Velocity = 0.76 fps, Avg. Travel Time= 23.3 min

Peak Storage= 7,967 cf @ 12.38 hrs
Average Depth at Peak Storage= 1.05'
Bank-Full Depth= 2.00' Flow Area= 20.0 sf, Capacity= 54.71 cfs

4.00' x 2.00' deep channel, n= 0.080 Earth, long dense weeds
Side Slope Z-value= 3.0 '/' Top Width= 16.00'
Length= 1,060.0' Slope= 0.0170 '/'
Inlet Invert= 435.00', Outlet Invert= 417.00'

‡

Summary for Reach 20R: Northern Wetland

Inflow Area = 940,975 sf, 0.00% Impervious, Inflow Depth > 3.45" for 100-Year event
Inflow = 38.48 cfs @ 12.27 hrs, Volume= 270,445 cf
Outflow = 38.48 cfs @ 12.27 hrs, Volume= 270,445 cf, Atten= 0%, Lag= 0.0 min

Routing by Stor-Ind+Trans method, Time Span= 5.00-24.00 hrs, dt= 0.05 hrs

Summary for Reach 21R: Northern Swale

Inflow Area = 403,012 sf, 0.00% Impervious, Inflow Depth > 3.69" for 100-Year event
Inflow = 24.91 cfs @ 12.34 hrs, Volume= 124,086 cf
Outflow = 22.50 cfs @ 12.60 hrs, Volume= 122,970 cf, Atten= 10%, Lag= 15.9 min

Routing by Stor-Ind+Trans method, Time Span= 5.00-24.00 hrs, dt= 0.05 hrs
Max. Velocity= 2.07 fps, Min. Travel Time= 9.0 min
Avg. Velocity = 0.85 fps, Avg. Travel Time= 21.9 min

Peak Storage= 12,205 cf @ 12.45 hrs
Average Depth at Peak Storage= 1.35'
Bank-Full Depth= 2.00' Flow Area= 20.0 sf, Capacity= 51.61 cfs

4.00' x 2.00' deep channel, n= 0.080 Earth, long dense weeds
Side Slope Z-value= 3.0 '/' Top Width= 16.00'
Length= 1,125.0' Slope= 0.0151 '/'
Inlet Invert= 433.00', Outlet Invert= 416.00'

‡

Summary for Pond 11P: Sedimentation Basin

Inflow Area = 248,891 sf, 0.00% Impervious, Inflow Depth > 3.56" for 100-Year event
Inflow = 14.40 cfs @ 12.53 hrs, Volume= 73,873 cf
Outflow = 13.29 cfs @ 12.66 hrs, Volume= 71,909 cf, Atten= 8%, Lag= 7.7 min
Primary = 13.29 cfs @ 12.66 hrs, Volume= 71,909 cf

Routing by Stor-Ind method, Time Span= 5.00-24.00 hrs, dt= 0.05 hrs
Peak Elev= 417.77' @ 12.66 hrs Surf.Area= 4,910 sf Storage= 12,454 cf

Plug-Flow detention time= 35.6 min calculated for 71,721 cf (97% of inflow)
Center-of-Mass det. time= 21.3 min (875.8 - 854.6)

Volume	Invert	Avail.Storage	Storage Description
#1	413.00'	16,493 cf	**Custom Stage Data (Prismatic)** Listed below (Recalc)

Elevation (feet)	Surf.Area (sq-ft)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)
413.00	0	0	0
414.00	1,762	881	881
415.00	2,318	2,040	2,921
416.00	2,930	2,624	5,545
417.00	3,996	3,463	9,008
418.00	5,177	4,587	13,595
418.50	6,415	2,898	16,493

Device	Routing	Invert	Outlet Devices
#1	Primary	417.50'	**20.0' long x 5.0' breadth Broad-Crested Rectangular Weir** Head (feet) 0.20 0.40 0.60 0.80 1.00 1.20 1.40 1.60 1.80 2.00 2.50 3.00 3.50 4.00 4.50 5.00 5.50 Coef. (English) 2.34 2.50 2.70 2.68 2.68 2.66 2.65 2.65 2.65 2.65 2.67 2.66 2.68 2.70 2.74 2.79 2.88
#2	Primary	414.25'	**12.0" Round 12" Culvert** L= 55.0' CPP, mitered to conform to fill, Ke= 0.700 Inlet / Outlet Invert= 414.25' / 414.25' S= 0.0000 '/' Cc= 0.900 n= 0.010 PVC, smooth interior, Flow Area= 0.79 sf
#3	Primary	414.00'	**4.0" Round 4" Culvert** L= 40.0' CPP, mitered to conform to fill, Ke= 0.700 Inlet / Outlet Invert= 414.00' / 414.00' S= 0.0000 '/' Cc= 0.900 n= 0.010 PVC, smooth interior, Flow Area= 0.09 sf

Primary OutFlow Max=13.14 cfs @ 12.66 hrs HW=417.77' (Free Discharge)
- **1=Broad-Crested Rectangular Weir** (Weir Controls 6.75 cfs @ 1.25 fps)
- **2=12" Culvert** (Inlet Controls 5.80 cfs @ 7.38 fps)
- **3=4" Culvert** (Barrel Controls 0.59 cfs @ 6.71 fps)

Summary for Pond 21P: Sedimentation Basin

Inflow Area = 403,012 sf, 0.00% Impervious, Inflow Depth > 3.66" for 100-Year event
Inflow = 22.50 cfs @ 12.60 hrs, Volume= 122,970 cf
Outflow = 22.00 cfs @ 12.67 hrs, Volume= 118,267 cf, Atten= 2%, Lag= 4.2 min
Primary = 22.00 cfs @ 12.67 hrs, Volume= 118,267 cf

Routing by Stor-Ind method, Time Span= 5.00-24.00 hrs, dt= 0.05 hrs
Peak Elev= 415.88' @ 12.67 hrs Surf.Area= 6,891 sf Storage= 18,352 cf

Plug-Flow detention time= 42.5 min calculated for 118,267 cf (96% of inflow)
Center-of-Mass det. time= 22.3 min (878.2 - 855.9)

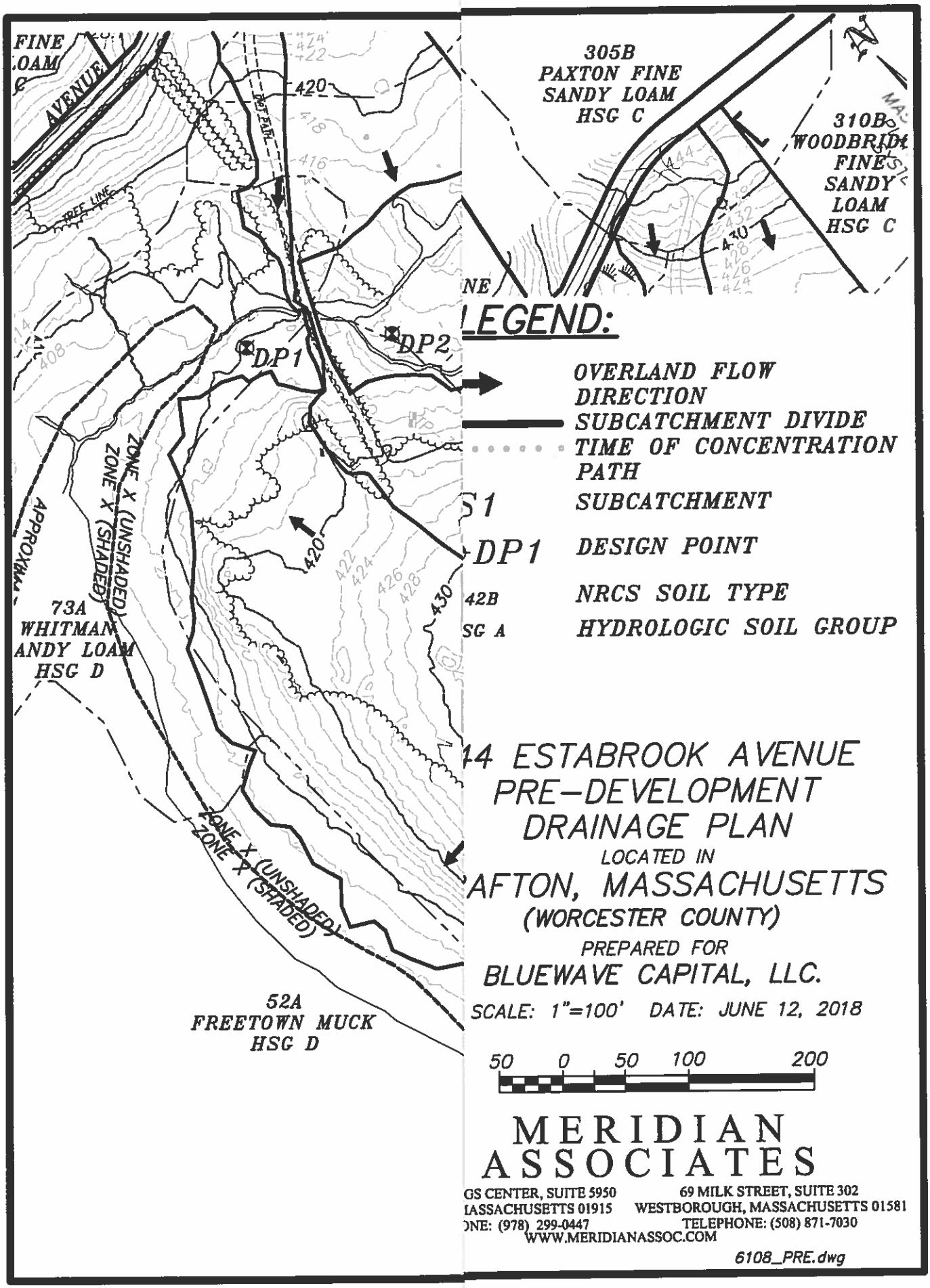
Volume	Invert	Avail.Storage	Storage Description
#1	412.00'	22,938 cf	**Custom Stage Data (Prismatic)**Listed below (Recalc)

Elevation (feet)	Surf.Area (sq-ft)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)
412.00	0	0	0
413.00	4,400	2,200	2,200
414.00	5,211	4,806	7,006
415.00	6,079	5,645	12,651
416.00	7,003	6,541	19,192
416.50	7,984	3,747	22,938

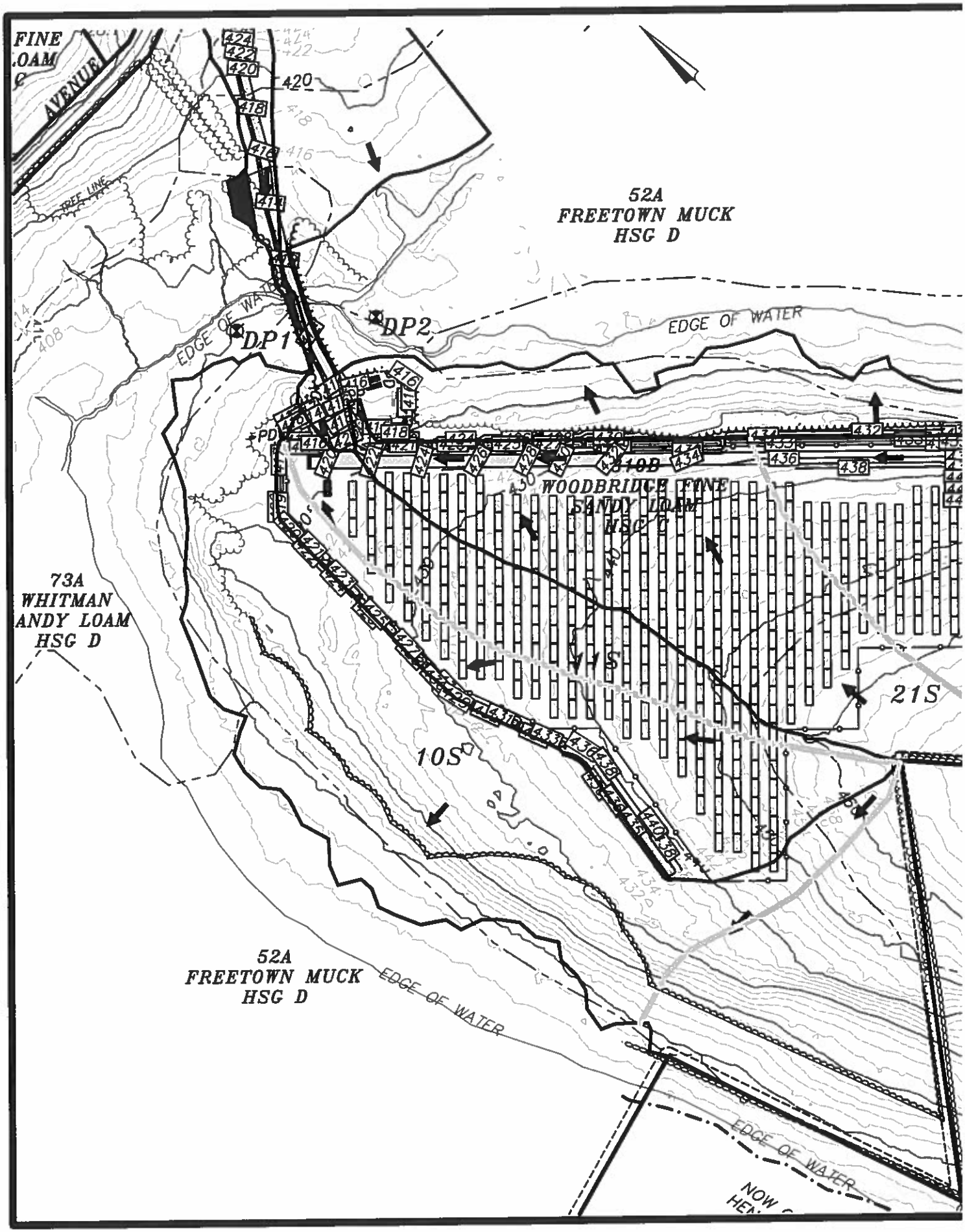
Device	Routing	Invert	Outlet Devices
#1	Primary	415.50'	**20.0' long x 6.0' breadth Broad-Crested Rectangular Weir** Head (feet) 0.20 0.40 0.60 0.80 1.00 1.20 1.40 1.60 1.80 2.00 2.50 3.00 3.50 4.00 4.50 5.00 5.50 Coef. (English) 2.37 2.51 2.70 2.68 2.68 2.67 2.65 2.65 2.65 2.65 2.66 2.66 2.67 2.69 2.72 2.76 2.83
#2	Primary	413.25'	**12.0" Round 12" Culvert X 2.00** L= 20.0' CPP, mitered to conform to fill, Ke= 0.700 Inlet / Outlet Invert= 413.25' / 413.25' S= 0.0000 '/' Cc= 0.900 n= 0.010 PVC, smooth interior, Flow Area= 0.79 sf
#3	Primary	413.00'	**4.0" Round 4" Culvert** L= 20.0' CPP, mitered to conform to fill, Ke= 0.700 Inlet / Outlet Invert= 413.00' / 413.00' S= 0.0000 '/' Cc= 0.900 n= 0.010 PVC, smooth interior, Flow Area= 0.09 sf

Primary OutFlow Max=21.72 cfs @ 12.67 hrs HW=415.87' (Free Discharge)
- **1=Broad-Crested Rectangular Weir** (Weir Controls 11.38 cfs @ 1.52 fps)
- **2=12" Culvert** (Inlet Controls 9.73 cfs @ 6.19 fps)
- **3=4" Culvert** (Inlet Controls 0.61 cfs @ 6.99 fps)

PRE-DEVELOPMENT
DRAINAGE PLAN


305B
PAXTON FINE
SANDY LOAM
HSG C
310B
WOODBRIDGE
FINE
SANDY
LOAM
HSG C
AVENUE
TREE LINE
DP1
DP2
420
430
ZONE X (UNSHADED)
ZONE X (SHADED)
73A
WHITMAN
ANDY LOAM
HSG D
52A
FREETOWN MUCK
HSG D
LEGEND:
OVERLAND FLOW DIRECTION
SUBCATCHMENT DIVIDE
TIME OF CONCENTRATION PATH
SUBCATCHMENT
DESIGN POINT
NRCS SOIL TYPE
HYDROLOGIC SOIL GROUP
14 ESTABROOK AVENUE
PRE-DEVELOPMENT
DRAINAGE PLAN
LOCATED IN
AFTON, MASSACHUSETTS
(WORCESTER COUNTY)
PREPARED FOR
BLUEWAVE CAPITAL, LLC.
SCALE: 1"=100' DATE: JUNE 12, 2018
50 0 50 100 200
MERIDIAN
ASSOCIATES
GS CENTER, SUITE 5950
IASSACHUSETTS 01915
ONE: (978) 299-0447
69 MILK STREET, SUITE 302
WESTBOROUGH, MASSACHUSETTS 01581
TELEPHONE: (508) 871-7030
WWW.MERIDIANASSOC.COM
6108_PRE.dwg

POST-DEVELOPMENT DRAINAGE PLAN


FINE
.OAM
C
AVENUE
TREE LINE
52A
FREETOWN MUCK
HSG D
DP1
DP2
EDGE OF WATER
EDGE OF WATER
PD
10D
WOODBRIDGE FINE
SANDY LOAM
HSG C
73A
WHITMAN
ANDY LOAM
HSG D
1S
21S
10S
52A
FREETOWN MUCK
HSG D
EDGE OF WATER
EDGE OF WATER

APPENDIX

OPERATION & MAINTENANCE PROGRAM

OPERATION AND MAINTENANCE PROGRAM
for
A PROPOSED STORMWATER MANAGEMENT SYSTEM
located at
44 ESTABROOK AVENUE
GRAFTON, MASSACHUSETTS

Prepared for:

BlueWave Capital, LLC
75 Arlington Street
Boston, Massachusetts 02116

Prepared by:

Meridian Associates, Inc.
500 Cummings Center, Suite 5950
Beverly, Massachusetts 01915
(978) 299-0447

June 12, 2018

Project Name: Knowlton Farms Solar Development (Phase 3)
44 Estabrook Avenue
Grafton, Ma 01519

Owner Name: Patricia K. Knowlton, Trustee - Knowlton Farms Nominee Trust
44 Estabrook Avenue
Grafton, Ma 01519

Party Responsible for Maintenance During Construction:
BlueWave Capital, LLC
75 Arlington Street
Boston, Massachusetts 02116

Party Responsible for Maintenance After Construction:
BlueWave Capital, LLC
75 Arlington Street
Boston, Massachusetts 02116

Erosion and Sedimentation Control Measures during Construction Activities

Haybales

Staked haybales will be installed upgradient of the resource areas as depicted on the Erosion & Sediment Control Plan. The haybales shall be installed prior to the commencement of any work on-site and in accordance with the design plans. An additional supply of haybales shall be on-site to replace and/or repair any haybales that have been disturbed or are in poor condition. The line of haybales shall be inspected and maintained on a weekly basis and after every major storm event (2-year or greater) during construction. No construction activities are to occur beyond the haybale line at any time. Deposited sediments shall be removed when the volume of the deposition reaches approximately one-half the height of the hay bale.

Water Quality Swales with Checkdams

The Water Quality Swales shall be checked weekly and after major storm events during construction for rilling, erosion, and debris removal. Avoid compaction of the parent material by working from the edge of the areas proposed as the locations of the Water Quality Swales. Debris and sediment accumulated at the checkdams is to be removed.

Sedimentation Basins

The Sedimentation Basin shall be checked weekly and after major storm events during construction for rilling, erosion, and debris removal. Avoid compaction of the parent

material by working from the edge of the areas proposed as the locations of the Sedimentation Basins.

Temporary Diversion Swales

Swales shall be checked weekly and after every major storm event during construction for rilling, gullying, erosion and debris removal.

Gravel Access Drive & Temporary Construction Parking Areas

The gravel access drive and temporary construction parking areas shall be inspected weekly. The access drive should be inspected for ruts, channelized drainage, gullying and sedimentation. Repairs to the drive and parking areas shall be made with new clean stone, and shall be compacted into place. Large ruts may be filled with larger stone and set in place with dense grade material, then overlain by new crushed stone.

Stockpiles

All unused debris, soil, and other material shall be stockpiled in locations of relatively flat grades, away from any trees identified to be saved and upgradient of the haybales. Stockpile side slopes shall not be greater than 2:1. All stockpiles shall be surrounded by a row of haybales, and shall be placed outside the 100 foot buffer to any bordering vegetated wetland. Surrounding haybales shall be inspected and maintained on a daily basis.

Surface Stabilization

Once the forested areas have been cleared and grubbed, the entire area will be tilled following the installation of the array; areas of exposed soils will be seeded with the *Solar Farm Seed Mix* provided by Ersnt Conservation Seeds. This seed mix contains a variety of low-growing, low-maintenance fescues that will stabilize the ground surface.

Construction Tracking Pad

Construction tracking pads shall be installed at the designated entrances/exits to the site at Cape Road and on both sides of the wetland crossing, as shown on the Erosion & Sediment Control plans to reduce the amount of sediment transported off site. The construction tracking pads shall be inspected weekly.

Removal of Sediment and Erosion Controls

At the completion of construction activities and after receiving approval from the Town of Mendon, all physical sediment and erosion controls shall be removed from the site. The areas where the controls have been removed shall be seeded and stabilized immediately upon removal.

Long-Term Inspection and Maintenance Measures after Construction

Erosion Control

Eroded sediments can adversely affect the performance of the stormwater management system. Eroding or barren areas should be immediately re-vegetated.

Gravel Access Drive

The gravel access drive shall be inspected bi-annually and after every major storm event for ruts, channelized drainage, gullying and sedimentation. Repairs to the drive shall be made with new clean stone, and shall be compacted into place. Large ruts may be filled with larger stone and set in place with dense grade material, then overlain by new crushed stone.

Water Quality Swales with Checkdams

The Sedimentation Basin shall be checked bi-annually and after every major storm event for rilling, gullying, erosions and debris removal. Maintenance mowing shall occur at a minimum of twice per year.

Sedimentation Basins

The Sedimentation Basin shall be checked bi-annually and after every major storm event for rilling, gullying, erosions and debris removal. Maintenance mowing shall occur at a minimum of twice per year.

Debris and Litter Removal

Trash may collect in the BMP's, potentially causing clogging of the facilities. All debris and litter shall be removed when necessary, and after each storm event. Sediment and debris collected from vacuuming and/or sweeping should be disposed of at a permitted waste disposal facility. Avoid disposing of this material on site, where it could be washed into the proposed detention basin.

Solar Farm Seed Mix Grass Mowing

Grass shall be inspected annually and maintenance mowing shall occur as needed. All lawn mowing to take place will be done with a mulch mower so grass clippings will not be an issue.

Good Housekeeping Practices (in accordance with Standard 10 of the Stormwater Management Handbook to prevent illicit discharges)

Provisions for storing paints, cleaners, automotive waste and other potentially hazardous household waste products inside or under cover

- All materials on site will be stored inside in a neat, orderly, manner in their appropriate containers with the original manufacturer's label.
- Only store enough material necessary. Whenever possible, all of a product shall be used up before disposing of container.
- Manufacturer, local, and State recommendations for proper use and disposal shall be followed.

Vehicle washing controls

- A commercial car wash shall be used when possible. Car washes treat and/or recycle water.
- Cars shall be washed on gravel, grass, or other permeable surfaces to allow filtration to occur.
- Use biodegradable soaps.
- A water hose with a nozzle that automatically turns off when left unattended.

Requirements for routine inspection and maintenance of stormwater BMPs

See Inspection and Maintenance Measures after Construction.

Spill prevention and response plans

Spill Control Practices shall be in conformance with the guidelines set forth in the National Pollutant Discharge Elimination System (NPDES) Stormwater Pollution Prevention Plan (SWPPP)

Provisions for maintenance of lawns, gardens, and other landscaped areas

- Grass shall not be cut shorter than 2 to 3 inches and mulch clipping should be left on lawn as a natural fertilizer.
- Use low volume water approaches such as drip-type or sprinkler systems. Water plants only when needed to enhance root growth and avoid runoff problems.
- The use of mulch shall be utilized where possible. Mulch helps retain water and prevents erosion.

Requirements for storage and use of fertilizers, herbicides and pesticides

- Fertilizers used will be applied only in the minimum amounts recommended by the manufacturer. Once applied, fertilizer will be worked into the soil to limit exposure to storm water. Storage will be in a covered shed. The contents of any partially used bags of fertilizer will be transferred to a sealable plastic bin to avoid spills.
- Do not fertilize before a rainstorm.
- Consider using organic fertilizers. They release nutrients more slowly.
- Pesticides shall be applied on lawns and gardens only when necessary and applied only in the minimum amounts recommended by the manufacturer.

Pet waste management

- Scoop up and seal pet wastes in a plastic bag. Dispose of properly, in the garbage.

Provisions for operation and management of septic systems

Not Applicable

Provisions for solid waste management

- All solid waste shall be disposed of or recycled in accordance with local town regulations.

Snow disposal and plowing plans relative to Resource Area

- Snow shall be plowed and stored on gravel, grass, or other permeable surfaces to allow filtration to occur.
- Once snow melts all sand salt and debris shall be extracted from surface and properly disposed of.
- Snow shall not be disposed of in any resource area or waterbody.
- Avoid disposing snow on top of storm drain catchbasins or stormwater drainage swale.

Winter Road Salt and/or Sand use and storage restrictions

- Salt storage piles should be located outside the 100-year buffer zone and shall be covered at all times.
- The amount of road salt applied should be regulated to prevent over salting of roadways and increasing runoff concentrations. Alternative materials, such as sand or gravel, should be used in especially sensitive areas.

Roadway and Parking Lot sweeping schedule

- Pavement sweeping shall be conducted at a frequency of not less than once per year.
- Removal of any accumulated sand, grit, and debris from driveway after the snow melts shall be completed shortly after snow melts for the season.

Documentation that Stormwater BMPs are designed to provide for shutdown and containment in the event of a spill or discharges to or near critical areas or from LUHPPL

Not Applicable

Training for staff or personnel involved with implementing Long-Term Pollution Prevention Plan

To be determined by the owner.

List of Emergency contacts for implementing Long-Term Pollution Prevention Plan

To be determined by the owner.

STORMWATER MANAGEMENT
CONSTRUCTION PHASE

INSPECTION SCHEDULE AND EVALUATION CHECKLIST

PROJECT LOCATION: 44 Estabrook Avenue, Grafton, Massachusetts **WEATHER:** _____

Inspection Date	*Inspector*	*Area Inspected*	*Required Inspection Frequency if BMP*	*Comments*	*Recommendation*	*Follow-up Inspection Required (yes/no)*
		Haybales	*Weekly and After Major Storm Events*			
		Construction Tracking Pads	*Weekly and After Major Storm Events*			
		Gravel Access Drive and Temporary Parking Areas	*Weekly and After Major Storm Events*			
		Water Quality Swales	*Weekly and After Major Storm Events*			
		Sedimentation Basin	*Weekly and After Major Storm Events*			
		Temporary Diversion Swales	*Weekly and After Major Storm Events*			

(1) Refer to the Massachusetts Stormwater Handbook, Volume Two: Stormwater Technical Handbook (February 2008) for recommendations regarding frequency for inspection and maintenance of specific BMP's.

(2) Inspections to be conducted by a qualified professional such as an environmental scientist or civil engineer.

Limited or no use of sodium chloride salts, fertilizers or pesticides recommended.

Other notes: (Include deviations from: Con. Comm. Order of Conditions, PB Approval, Construction Sequence and Approved Plan)

Stormwater Control Manager: _____

STORMWATER MANAGEMENT
AFTER CONSTRUCTION

INSPECTION SCHEDULE AND EVALUATION CHECKLIST

PROJECT LOCATION: 44 Estabrook Avenue, Grafton, Massachusetts **WEATHER:**_____

Inspection Date	*Inspector*	*Area Inspected*	*Required Inspection Frequency if BMP*	*Comments*	*Recommendation*	*Follow-up Inspection Required (yes/no)*
		Sedimentation Basin	*Bi-annually and After Major Storm Event*			
		Gravel Access Drive	*Bi-annually and After Major Storm Event*			
		Water Quality Swales	*Bi-annually and After Major Storm Event*			

(1) Refer to the Massachusetts Stormwater Handbook, Volume Two: Stormwater Technical Handbook (February 2008) for recommendations regarding frequency for inspection and maintenance of specific BMP's.

(2) Inspections to be conducted by a qualified professional such as an environmental scientist or civil engineer.

Limited or no use of sodium chloride salts, fertilizers or pesticides recommended.

Other notes: (Include deviations from: Con. Comm. Order of Conditions, PB Approval, Construction Sequence and Approved Plan)

Stormwater Control Manager: _____

STORMWATER MANAGEMENT STANDARDS

Stormwater Management Standards

Project Narrative:

This site is located at 44 Estabrook Avenue in Grafton, Massachusetts on an undeveloped parcel of land. The area is comprised of mostly grassed meadow surrounded by forest and low lying resource areas. The land currently slopes from east to west to two (2) wetland resource areas. Elevations on the site range from 480 along the eastern property line to an elevation of approximately 410 in the middle of the site.

The proposed project is comprised of the development of the existing land into a solar energy generating facility. The existing runoff patterns onsite will be maintained with limited selective grading. The proposed solar facility will be installed using a screw and post system providing low impact development on the existing topography of the locus area.

The proposed project is comprised of the development of a solar electric generating facility, the construction of a gravel access road, water quality swales and sedimentation basins, inverter/transformer stations, interconnection equipment, electrical conduit, new utility poles and risers, fencing, gates, and associated seeding and stabilization.

The solar energy generating facility has been designed and incorporated into the existing topography in order to manage stormwater runoff in an appropriate and responsible manner.

The following are the DEP Stormwater Standards as outlined in the Wetlands Regulations:

Standard 1: No new stormwater conveyances may discharge untreated stormwater directly to or cause erosion in wetlands or waters of the Commonwealth.

The existing project topography directs the stormwater runoff from the area of the proposed work across the site toward existing railroad tracks, wooded land, or Boston Post Road. There currently is no treatment of stormwater prior to discharge to these locations. The proposed conditions will not have a point source discharge and will direct stormwater in the same general patterns as the existing conditions, across proposed "solar farm mix" and wooded areas prior to discharging toward the design points.

Standard 2: Peak Rate Attenuation - Stormwater management systems shall be designed so that post-development peak discharge rates do not exceed pre-development peak discharge rates. This standard may be waived for discharges to land subject to coastal storm flowage as defined in 310 CMR 10.04.

For the purpose of analyzing pre and post development stormwater peak rates of runoff, two (2) design points have been selected based on existing topographic conditions and

was used for both the pre and the post calculations. Comparison values for pre and post development stormwater peak rates are given for the design points only.

The storm events used to calculate peak runoff rates for pre and post construction conditions have been selected based upon the Massachusetts Stormwater Guidelines requirements. Full detail of peak rate attenuation along with supplemental stormwater calculations utilizing HydroCAD as well as pre and post drainage site plans can be found in the appendix of this report. The details of this report show that the peak rates of runoff for the 2-year, 10-year and 100 year events have been matched or reduced from pre to post conditions.

The hydrologic calculations from HydroCAD has been included in the "Stormwater Analysis & Calculations Report".

Proposed Design Point and Subcatchment Areas

The proposed project is comprised of the development of a solar electric generating facility, the construction of a gravel access road, water quality swales, sedimentation basins, inverter/transformer stations, interconnection equipment, electrical conduit, new utility poles and risers, fencing, gates, and associated seeding and stabilization. The existing runoff patterns will be maintained with limited selective grading. The proposed solar facility will be installed using a screw and/or post system which minimizes impact on the existing topography and reduces the need for excess earthwork.

A drainage system consisting of water quality swales and sedimentation basins are proposed to provide water quality treatment for the gravel access drive as well as nitrogen removal. Additionally, peak rates of stormwater runoff in the proposed conditions will not result in an increase in the 2, 10, and 100-year storm events at the selected design points.

The proposed site has been broken into subcatchments as depicted on the Post-Development Drainage Plan. The following summarizes the various hydraulic conditions and areas comprising the post-hydrologic model.

- **Subcatchment S10** – This is denoted as S10 on the accompanying Pre-Development Drainage Plan. The subcatchment area consists of wooded land, meadow grass and "Solar Farm Seed Mix" grassed areas and "Wetmix" grassed areas, portions of the gravel drive, water quality swale and sedimentation basin. Stormwater runoff generated in this subcatchment flows to the existing resource area to the north of the field and south of Estabrook Avenue. **(DP10).**

- **Subcatchment S20** – This is denoted as S10 on the accompanying Pre-Development Drainage Plan. The subcatchment area consists of wooded land, meadow grass and "Solar Farm Seed Mix" grassed areas and "Wetmix" grassed areas, portions of the gravel drive, water quality swale and sedimentation basin.

Stormwater runoff generated in this subcatchment flows to the existing resource area to the west/northwest of the field and south of Estabrook Avenue. **(DP20).**

Summary of Flows at Design Points 1 and 10

Storm Event	Existing Conditions (Pre) Peak Flow (CFS)	Proposed Conditions (Post) Peak Flow (CFS)
2-Year (3.00 in./hr.)	12.44	11.25
10-Year (4.50 in./hr.)	30.64	26.85
100-Year (6.50 in./hr.)	58.64	52.16

Summary of Flows at Design Points 2 and 20

Storm Event	Existing Conditions (Pre) Peak Flow (CFS)	Proposed Conditions (Post) Peak Flow (CFS)
2-Year (3.00 in./hr.)	10.08	7.28
10-Year (4.50 in./hr.)	25.38	18.05
100-Year (6.50 in./hr.)	49.26	38.48

* CFS – Cubic Feet Per Second
* AF – Acre Feet

The table above outline the results of the hydrologic model. As required by Standard #2, the project has adequately attenuated for potential increase in peak stormwater flows.

Standard 3: Recharge - Loss of annual recharge to groundwater shall be eliminated or minimized…at a minimum, the annual recharge from the post-development site shall approximate the annual recharge from pre-development conditions based on soil type. This standard is met when the stormwater management system is designed to infiltrate the required recharge volume in accordance with the Mass Stormwater Handbook.

Meridian Associates reviewed soils data from the United States Department of Agriculture Natural Resources Conservation Service and determined that onsite depth to groundwater can range from eighteen (18) inches to thirty-seven (37) inches. The majority of the onsite soils are in the Hydraulic Soil Group C with some pockets of D soil. With that said, the amount of groundwater recharge that would be required is negligible.

Standard 4: Water Quality – Stormwater management systems shall be designed to remove 80% of the average annual post-construction load of Total Suspended Solids

(TSS). The standard is met with pollution prevention plans, stormwater BMP's sized to capture required water quality volume, and pretreatment measures.

The project proposes a minimal amount of impervious area (1,500 s.f.) for the concrete equipment pads. Therefore, with the stormwater traveling over hundreds of feet of naturally vegetated land cover prior to discharging to the existing wetlands will accommodate for any minor TSS needed to be removed. The amount of TSS removal that would be required is negligible.

Standard 5: Land Uses with Higher Potential Pollutant Loads (LUHPPLs) – Source control and pollution prevention shall be implemented in accordance with the Stormwater Handbook to eliminate or reduce the discharge of stormwater runoff from such land uses to the maximum extent practicable.

Stormwater Standard 5 is not applicable to this project. The proposed development will not subject the site to higher potential pollutant loads as defined in the Massachusetts Department of Environmental Protection Wetlands and Water Quality Regulations.

LUHPPLs are identified in 310 CMR 22.20B(2) and C(2)(a)-(k) and (m) and CMR 22.21(2)(a)(1)-(8) and (b)(1)-(6), areas within a site that are the location of activities that are subject to an individual National Pollutant Discharge Elimination System (NPDES) permit or the NPDES Multi-sector General Permit; auto fueling facilities, exterior fleet storage areas, exterior vehicle service and equipment cleaning areas; marinas and boatyards; parking lots with high-intensity-use; confined disposal facilities and disposal sites.

Standard 6: Critical Areas – Stormwater discharges to critical areas require the use of specific source control and pollution prevention measures and specific structural stormwater best management practices determined by the Department to be suitable for managing discharges to such areas.

Stormwater Standard 6 is not applicable to this project given that proposed stormwater does not discharge near a critical area. Critical areas being Outstanding Resource Waters and Special Resource Waters as designated in 314 CMR 4.0, recharge areas for public water supplies as defined in 310 CMR 22.02, bathing beaches as defined in 105 CMR 445.000, cold-water fisheries and shellfish growing areas as defined in 314 CMR 9.02 and 310 CMR 10.04. The existing wetlands and river are not considered critical areas therefore Standard #6 does not apply to this project.

Standard 7: Redevelopments – A redevelopment project is required to meet Standards 1-6 only to the maximum extent practicable. Remaining standards shall be met as well as the project shall improve the existing conditions.

Stormwater Standard 7 is not applicable to this project. Within the Stormwater Management Handbook (volume 1 chapter 1 page 20), the definition of a redevelopment project includes, "development, rehabilitation, expansion and phased projects on

previously developed sites, provided the redevelopment results in no net increase in impervious area".

This project will not result in a reduction of impervious area in the proposed conditions.

Standard 8: Construction Period Pollution Prevention and Erosion and Sedimentation Control Plan shall be implemented.

An *Operation and Maintenance Program* is included with this report. The program details the construction period operation and maintenance plan and sequencing for pollution prevention measures and erosion and sedimentation controls. Locations of erosion control measures for the project are depicted on the site plan set accompanying this report.

Standard 9: A long term Operation and Maintenance Plan shall be implemented.

An *Operation and Maintenance Program for a Proposed Stormwater Management System* is included with this report. The long term operation and maintenance section of the program provides details and the schedule for routine and non-routine maintenance tasks to be implemented at the completion of the project.

Standard 10: Prohibition of Illicit Discharges – Illicit discharges to the stormwater management system are prohibited.

Illicit discharges to the stormwater management system are discharges that are not entirely comprised of stormwater. Discharges to the stormwater management system from the following activities or facilities are permissible: Firefighting, water line flushing, landscape irrigation, uncontaminated groundwater, potable water sources, foundation drains, air conditioning condensation, footing drains, individual resident car washing, flows from riparian habitats and wetlands, dechlorinated water from swimming pools, water used for street washing and water used to clean residential buildings without detergents. All other illicit discharges are prohibited.

There are no known illicit discharges anticipated through the completion of this project. During construction and post construction procedures are provided to dissipate the potential for illicit discharges to the drainage system. Post construction preventions of illicit discharges are described in the Operation and Maintenance Program under the Good Housekeeping Practices section of the report.

CHECKLIST FOR STORMWATER REPORT

Massachusetts Department of Environmental Protection
Bureau of Resource Protection - Wetlands Program

Checklist for Stormwater Report

A. Introduction

Important: When filling out forms on the computer, use only the tab key to move your cursor - do not use the return key.

A Stormwater Report must be submitted with the Notice of Intent permit application to document compliance with the Stormwater Management Standards. The following checklist is NOT a substitute for the Stormwater Report (which should provide more substantive and detailed information) but is offered here as a tool to help the applicant organize their Stormwater Management documentation for their Report and for the reviewer to assess this information in a consistent format. As noted in the Checklist, the Stormwater Report must contain the engineering computations and supporting information set forth in Volume 3 of the Massachusetts Stormwater Handbook. The Stormwater Report must be prepared and certified by a Registered Professional Engineer (RPE) licensed in the Commonwealth.

The Stormwater Report must include:

- The Stormwater Checklist completed and stamped by a Registered Professional Engineer (see page 2) that certifies that the Stormwater Report contains all required submittals.[1] This Checklist is to be used as the cover for the completed Stormwater Report.
- Applicant/Project Name
- Project Address
- Name of Firm and Registered Professional Engineer that prepared the Report
- Long-Term Pollution Prevention Plan required by Standards 4-6
- Construction Period Pollution Prevention and Erosion and Sedimentation Control Plan required by Standard 8[2]
- Operation and Maintenance Plan required by Standard 9

In addition to all plans and supporting information, the Stormwater Report must include a brief narrative describing stormwater management practices, including environmentally sensitive site design and LID techniques, along with a diagram depicting runoff through the proposed BMP treatment train. Plans are required to show existing and proposed conditions, identify all wetland resource areas, NRCS soil types, critical areas, Land Uses with Higher Potential Pollutant Loads (LUHPPL), and any areas on the site where infiltration rate is greater than 2.4 inches per hour. The Plans shall identify the drainage areas for both existing and proposed conditions at a scale that enables verification of supporting calculations.

As noted in the Checklist, the Stormwater Management Report shall document compliance with each of the Stormwater Management Standards as provided in the Massachusetts Stormwater Handbook. The soils evaluation and calculations shall be done using the methodologies set forth in Volume 3 of the Massachusetts Stormwater Handbook.

To ensure that the Stormwater Report is complete, applicants are required to fill in the Stormwater Report Checklist by checking the box to indicate that the specified information has been included in the Stormwater Report. If any of the information specified in the checklist has not been submitted, the applicant must provide an explanation. The completed Stormwater Report Checklist and Certification must be submitted with the Stormwater Report.

[1] The Stormwater Report may also include the Illicit Discharge Compliance Statement required by Standard 10. If not included in the Stormwater Report, the Illicit Discharge Compliance Statement must be submitted prior to the discharge of stormwater runoff to the post-construction best management practices.

[2] For some complex projects, it may not be possible to include the Construction Period Erosion and Sedimentation Control Plan in the Stormwater Report. In that event, the issuing authority has the discretion to issue an Order of Conditions that approves the project and includes a condition requiring the proponent to submit the Construction Period Erosion and Sedimentation Control Plan before commencing any land disturbance activity on the site.

Massachusetts Department of Environmental Protection
Bureau of Resource Protection - Wetlands Program

Checklist for Stormwater Report

B. Stormwater Checklist and Certification

The following checklist is intended to serve as a guide for applicants as to the elements that ordinarily need to be addressed in a complete Stormwater Report. The checklist is also intended to provide conservation commissions and other reviewing authorities with a summary of the components necessary for a comprehensive Stormwater Report that addresses the ten Stormwater Standards.

Note: Because stormwater requirements vary from project to project, it is possible that a complete Stormwater Report may not include information on some of the subjects specified in the Checklist. If it is determined that a specific item does not apply to the project under review, please note that the item is not applicable (N.A.) and provide the reasons for that determination.

A complete checklist must include the Certification set forth below signed by the Registered Professional Engineer who prepared the Stormwater Report.

Registered Professional Engineer's Certification

I have reviewed the Stormwater Report, including the soil evaluation, computations, Long-term Pollution Prevention Plan, the Construction Period Erosion and Sedimentation Control Plan (if included), the Long-term Post-Construction Operation and Maintenance Plan, the Illicit Discharge Compliance Statement (if included) and the plans showing the stormwater management system, and have determined that they have been prepared in accordance with the requirements of the Stormwater Management Standards as further elaborated by the Massachusetts Stormwater Handbook. I have also determined that the information presented in the Stormwater Checklist is accurate and that the information presented in the Stormwater Report accurately reflects conditions at the site as of the date of this permit application.

Registered Professional Engineer Block and Signature

David S. Kelley 06-12-18

Signature and Date

Checklist

Project Type: Is the application for new development, redevelopment, or a mix of new and redevelopment?

☒ New development

☐ Redevelopment

☐ Mix of New Development and Redevelopment

Checklist for Stormwater Report

Checklist (continued)

LID Measures: Stormwater Standards require LID measures to be considered. Document what environmentally sensitive design and LID Techniques were considered during the planning and design of the project:

- ☐ No disturbance to any Wetland Resource Areas
- ☐ Site Design Practices (e.g. clustered development, reduced frontage setbacks)
- ☐ Reduced Impervious Area (Redevelopment Only)
- ☐ Minimizing disturbance to existing trees and shrubs
- ☐ LID Site Design Credit Requested:
  - ☐ Credit 1
  - ☐ Credit 2
  - ☐ Credit 3
- ☐ Use of "country drainage" versus curb and gutter conveyance and pipe
- ☐ Bioretention Cells (includes Rain Gardens)
- ☐ Constructed Stormwater Wetlands (includes Gravel Wetlands designs)
- ☐ Treebox Filter
- ☐ Water Quality Swale
- ☐ Grass Channel
- ☐ Green Roof
- ☒ Other (describe): Low Impact Design screw & post racking system

Standard 1: No New Untreated Discharges

- ☒ No new untreated discharges
- ☐ Outlets have been designed so there is no erosion or scour to wetlands and waters of the Commonwealth
- ☐ Supporting calculations specified in Volume 3 of the Massachusetts Stormwater Handbook included.

necklist for Stormwater Report

cklist (continued)

dard 2: Peak Rate Attenuation

tandard 2 waiver requested because the project is located in land subject to coastal storm flowage nd stormwater discharge is to a wetland subject to coastal flooding.

valuation provided to determine whether off-site flooding increases during the 100-year 24-hour torm.

alculations provided to show that post-development peak discharge rates do not exceed pre-evelopment rates for the 2-year and 10-year 24-hour storms. If evaluation shows that off-site ooding increases during the 100-year 24-hour storm, calculations are also provided to show that ost-development peak discharge rates do not exceed pre-development rates for the 100-year 24-our storm.

dard 3: Recharge

☒ oil Analysis provided.

Required Recharge Volume calculation provided.

☐ Required Recharge volume reduced through use of the LID site Design Credits.

☐ izing the infiltration, BMPs is based on the following method: Check the method used.

☐ Static ☐ Simple Dynamic ☐ Dynamic Field[1]

☐ Runoff from all impervious areas at the site discharging to the infiltration BMP.

Runoff from all impervious areas at the site is *not* discharging to the infiltration BMP and calculations are provided showing that the drainage area contributing runoff to the infiltration BMPs is sufficient to generate the required recharge volume.

☐ Recharge BMPs have been sized to infiltrate the Required Recharge Volume.

☐ Recharge BMPs have been sized to infiltrate the Required Recharge Volume *only* to the maximum extent practicable for the following reason:

- ☐ Site is comprised solely of C and D soils and/or bedrock at the land surface
- ☐ M.G.L. c. 21E sites pursuant to 310 CMR 40.0000
- ☐ Solid Waste Landfill pursuant to 310 CMR 19.000
- ☐ Project is otherwise subject to Stormwater Management Standards only to the maximum extent practicable.

☐ Calculations showing that the infiltration BMPs will drain in 72 hours are provided.

☐ Property includes a M.G.L. c. 21E site or a solid waste landfill and a mounding analysis is included.

[1] % TSS removal is required prior to discharge to infiltration BMP if Dynamic Field method is used.

Checklist for Stormwater Report

Checklist (continued)

Standard 7: Redevelopments and Other Projects Subject to the Standards only to the maximum extent practicable

☐ The project is subject to the Stormwater Management Standards only to the maximum Extent Practicable as a:

- ☐ Limited Project
- ☐ Small Residential Projects: 5-9 single family houses or 5-9 units in a multi-family development provided there is no discharge that may potentially affect a critical area.
- ☐ Small Residential Projects: 2-4 single family houses or 2-4 units in a multi-family development with a discharge to a critical area
- ☐ Marina and/or boatyard provided the hull painting, service and maintenance areas are protected from exposure to rain, snow, snow melt and runoff
- ☐ Bike Path and/or Foot Path
- ☐ Redevelopment Project
- ☐ Redevelopment portion of mix of new and redevelopment.

☒ Certain standards are not fully met (Standard No. 1, 8, 9, and 10 must always be fully met) and an explanation of why these standards are not met is contained in the Stormwater Report.

☐ The project involves redevelopment and a description of all measures that have been taken to improve existing conditions is provided in the Stormwater Report. The redevelopment checklist found in Volume 2 Chapter 3 of the Massachusetts Stormwater Handbook may be used to document that the proposed stormwater management system (a) complies with Standards 2, 3 and the pretreatment and structural BMP requirements of Standards 4-6 to the maximum extent practicable and (b) improves existing conditions.

Standard 8: Construction Period Pollution Prevention and Erosion and Sedimentation Control

A Construction Period Pollution Prevention and Erosion and Sedimentation Control Plan must include the following information:

- Narrative;
- Construction Period Operation and Maintenance Plan;
- Names of Persons or Entity Responsible for Plan Compliance;
- Construction Period Pollution Prevention Measures;
- Erosion and Sedimentation Control Plan Drawings;
- Detail drawings and specifications for erosion control BMPs, including sizing calculations;
- Vegetation Planning;
- Site Development Plan;
- Construction Sequencing Plan;
- Sequencing of Erosion and Sedimentation Controls;
- Operation and Maintenance of Erosion and Sedimentation Controls;
- Inspection Schedule;
- Maintenance Schedule;
- Inspection and Maintenance Log Form.

☒ A Construction Period Pollution Prevention and Erosion and Sedimentation Control Plan containing the information set forth above has been included in the Stormwater Report.

Checklist for Stormwater Report

Checklist (continued)

Standard 8: Construction Period Pollution Prevention and Erosion and Sedimentation Control (continued)

☐ The project is highly complex and information is included in the Stormwater Report that explains why it is not possible to submit the Construction Period Pollution Prevention and Erosion and Sedimentation Control Plan with the application. A Construction Period Pollution Prevention and Erosion and Sedimentation Control has ***not*** been included in the Stormwater Report but will be submitted ***before*** land disturbance begins.

☐ The project is ***not*** covered by a NPDES Construction General Permit.

☐ The project is covered by a NPDES Construction General Permit and a copy of the SWPPP is in the Stormwater Report.

☒ The project is covered by a NPDES Construction General Permit but no SWPPP been submitted. The SWPPP will be submitted BEFORE land disturbance begins.

Standard 9: Operation and Maintenance Plan

☒ The Post Construction Operation and Maintenance Plan is included in the Stormwater Report and includes the following information:

- ☒ Name of the stormwater management system owners;
- ☒ Party responsible for operation and maintenance;
- ☒ Schedule for implementation of routine and non-routine maintenance tasks;
- ☒ Plan showing the location of all stormwater BMPs maintenance access areas;
- ☒ Description and delineation of public safety features;
- ☐ Estimated operation and maintenance budget; and
- ☒ Operation and Maintenance Log Form.

☐ The responsible party is ***not*** the owner of the parcel where the BMP is located and the Stormwater Report includes the following submissions:

- ☐ A copy of the legal instrument (deed, homeowner's association, utility trust or other legal entity) that establishes the terms of and legal responsibility for the operation and maintenance of the project site stormwater BMPs;
- ☐ A plan and easement deed that allows site access for the legal entity to operate and maintain BMP functions.

Standard 10: Prohibition of Illicit Discharges

☐ The Long-Term Pollution Prevention Plan includes measures to prevent illicit discharges;

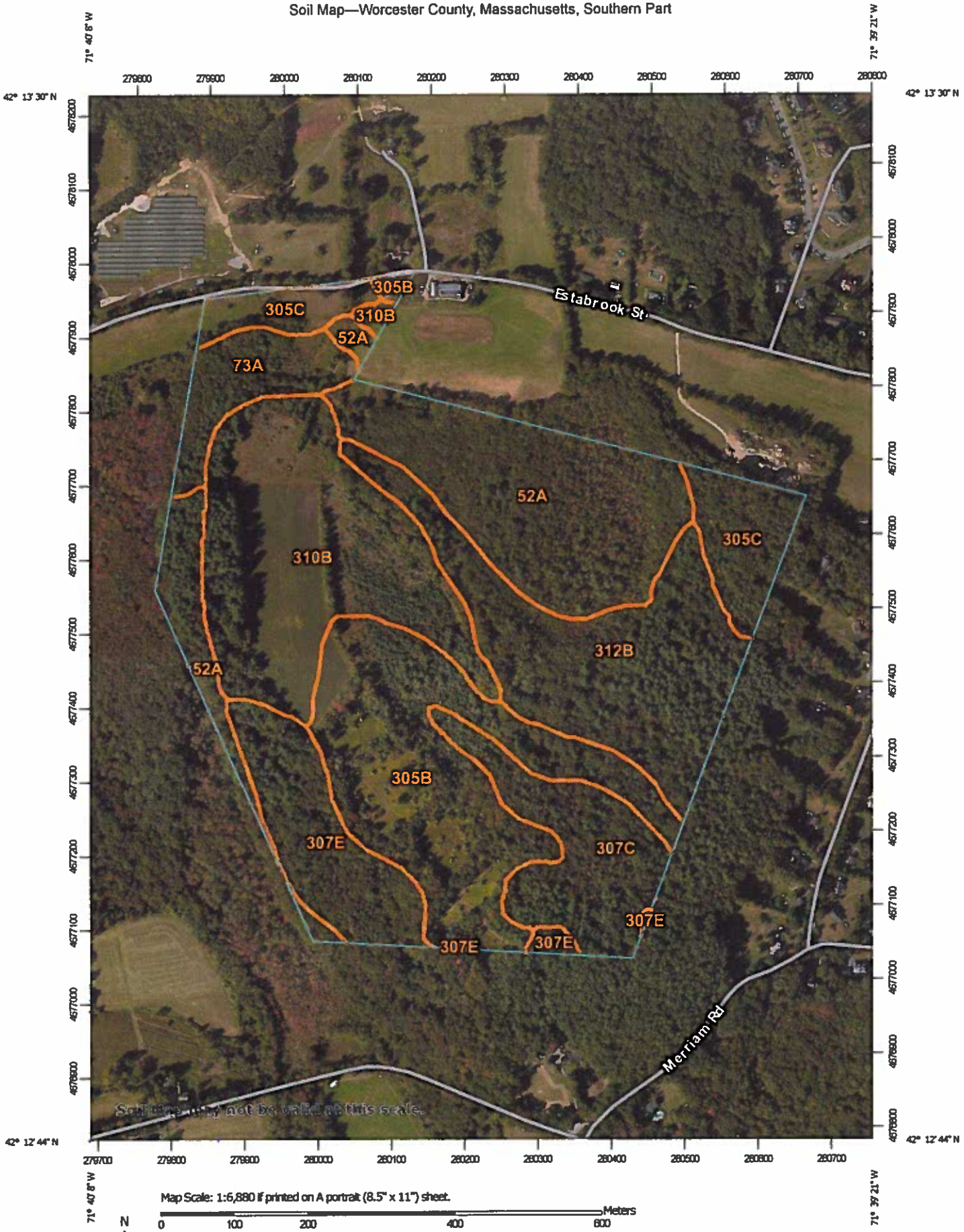
☐ An Illicit Discharge Compliance Statement is attached;

☒ NO Illicit Discharge Compliance Statement is attached but will be submitted ***prior to*** the discharge of any stormwater to post-construction BMPs.

USDA NATURAL RESOURCE CONSERVATION SERVICE

NATIONAL COOPERATIVE SOIL SURVEY

Soil Map—Worcester County, Massachusetts, Southern Part



MAP LEGEND

Area of Interest (AOI)
- Area of Interest (AOI)

Soils
- Soil Map Unit Polygons
- Soil Map Unit Lines
- Soil Map Unit Points

Special Point Features
- Blowout
- Borrow Pit
- Clay Spot
- Closed Depression
- Gravel Pit
- Gravelly Spot
- Landfill
- Lava Flow
- Marsh or swamp
- Mine or Quarry
- Miscellaneous Water
- Perennial Water
- Rock Outcrop
- Saline Spot
- Sandy Spot
- Severely Eroded Spot
- Sinkhole
- Slide or Slip
- Sodic Spot
- Spoil Area
- Stony Spot
- Very Stony Spot
- Wet Spot
- Other
- Special Line Features

Water Features
- Streams and Canals

Transportation
- Rails
- Interstate Highways
- US Routes
- Major Roads
- Local Roads

Background
- Aerial Photography

MAP INFORMATION

The soil surveys that comprise your AOI were mapped at 1:25,000.

Warning: Soil Map may not be valid at this scale.

Enlargement of maps beyond the scale of mapping can cause misunderstanding of the detail of mapping and accuracy of soil line placement. The maps do not show the small areas of contrasting soils that could have been shown at a more detailed scale.

Please rely on the bar scale on each map sheet for map measurements.

Source of Map: Natural Resources Conservation Service
Web Soil Survey URL:
Coordinate System: Web Mercator (EPSG:3857)

Maps from the Web Soil Survey are based on the Web Mercator projection, which preserves direction and shape but distorts distance and area. A projection that preserves area, such as the Albers equal-area conic projection, should be used if more accurate calculations of distance or area are required.

This product is generated from the USDA-NRCS certified data as of the version date(s) listed below.

Soil Survey Area: Worcester County, Massachusetts, Southern Part
Survey Area Data: Version 10, Oct 6, 2017

Soil map units are labeled (as space allows) for map scales 1:50,000 or larger.

Date(s) aerial images were photographed: Sep 12, 2014—Sep 28, 2014

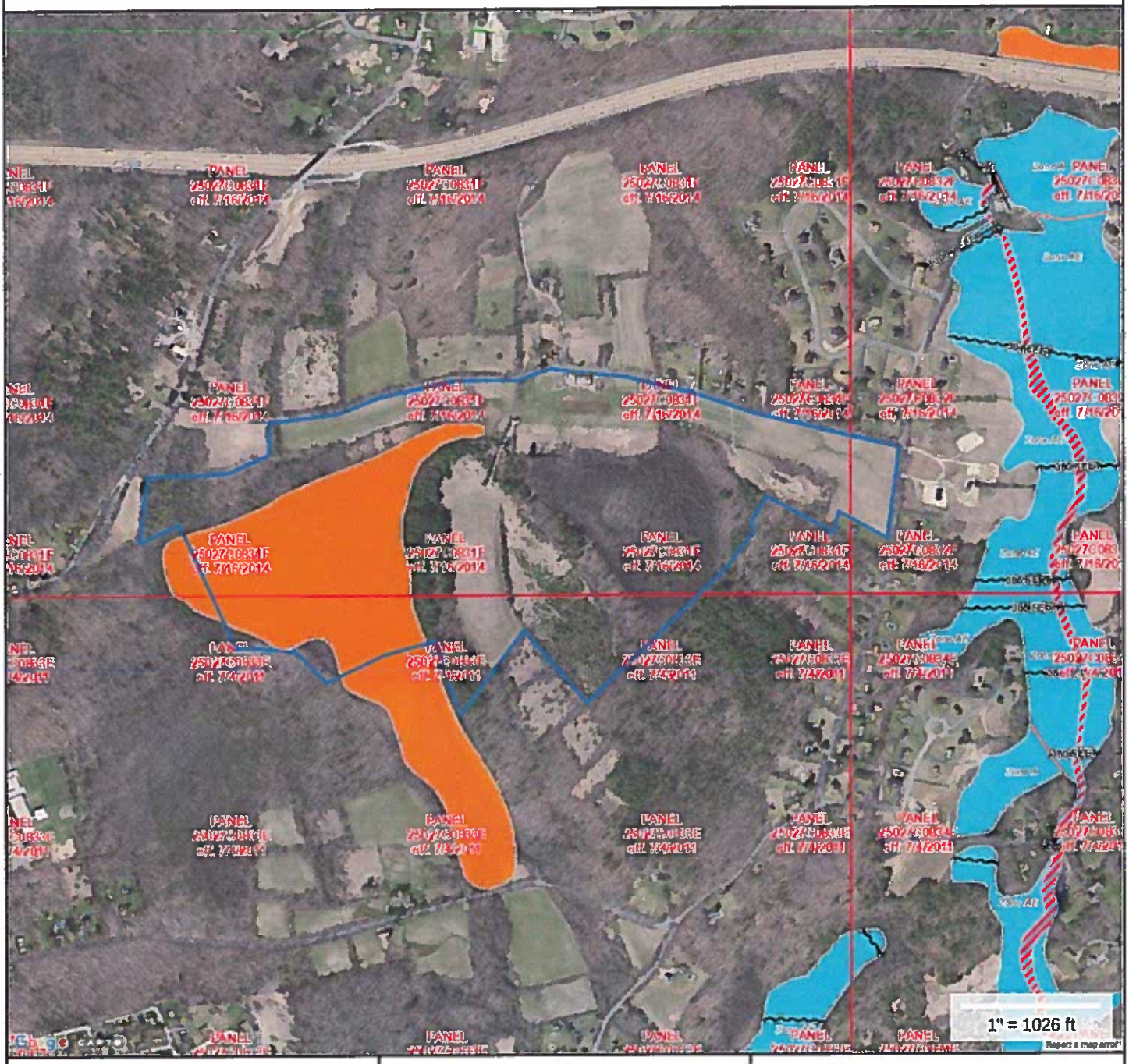
The orthophoto or other base map on which the soil lines were compiled and digitized probably differs from the background imagery displayed on these maps. As a result, some minor shifting of map unit boundaries may be evident.

Map Unit Legend

Map Unit Symbol	Map Unit Name	Acres in AOI	Percent of AOI
52A	Freetown muck, 0 to 1 percent slopes	25.8	19.4%
73A	Whitman fine sandy loam, 0 to 3 percent slopes, extremely stony	5.9	4.5%
305B	Paxton fine sandy loam, 3 to 8 percent slopes	24.9	18.8%
305C	Paxton fine sandy loam, 8 to 15 percent slopes	8.4	6.4%
307C	Paxton fine sandy loam, 8 to 15 percent slopes, extremely stony	10.8	8.1%
307E	Paxton fine sandy loam, 15 to 35 percent slopes, extremely stony	10.5	7.9%
310B	Woodbridge fine sandy loam, 3 to 8 percent slopes	25.2	19.0%
312B	Woodbridge fine sandy loam, 0 to 8 percent slopes, extremely stony	21.2	16.0%
Totals for Area of Interest		**132.7**	**100.0%**

FEDERAL EMERGENCY MANAGEMENT AGENCY

FLOOD INSURANCE RATE MAP



Property Information

Property ID	110/049.0-0000-0006.0
Location	44 ESTABROOK AVENUE
Owner	KNOWLTON PATRICIA K TRUSTEE

MAP FOR REFERENCE ONLY
NOT A LEGAL DOCUMENT

Town of Grafton, MA makes no claims and no warranties, expressed or implied, concerning the validity or accuracy of the GIS data presented on this map.

Parcels updated 4/1/2018
Properties updated 4/1/2018